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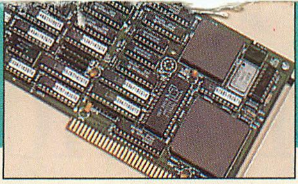

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JANUARY 1988

VOL. 6 NO. 1 $3.95

PC TECH JOURNAL®

FOR SYSTEMS DEVELOPERS AND INTEGRATORS

OS/2 ALTERNATIVES

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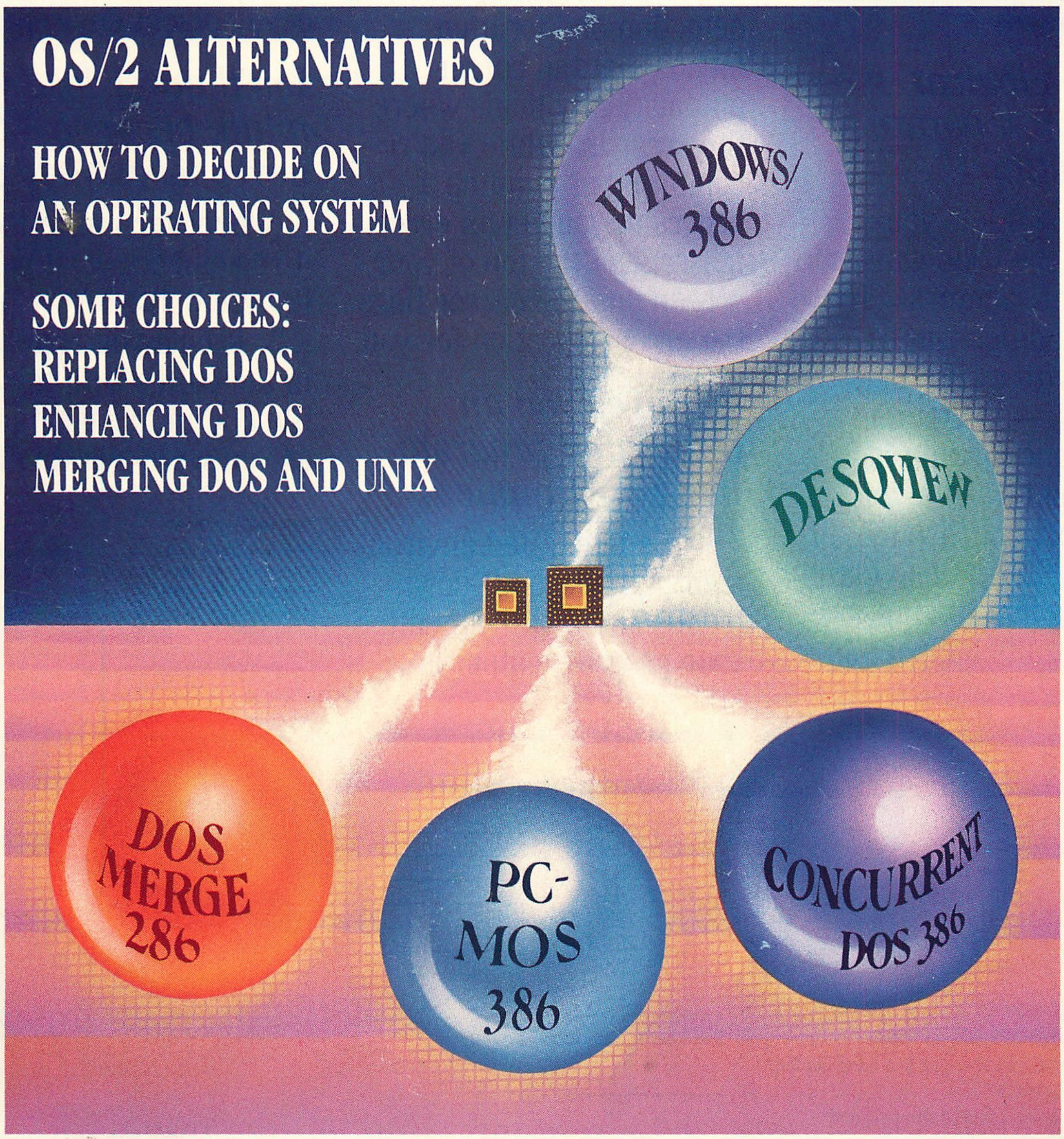
SOME CHOICES:
REPLACING DOS
ENHANCING DOS
MERGING DOS AND UNIX



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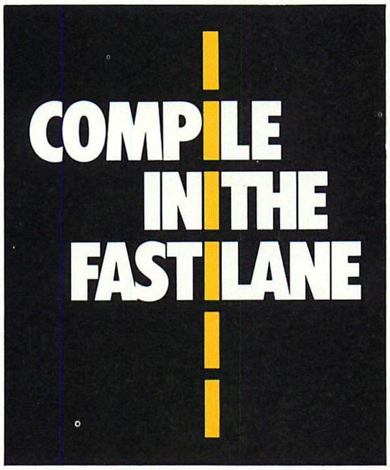

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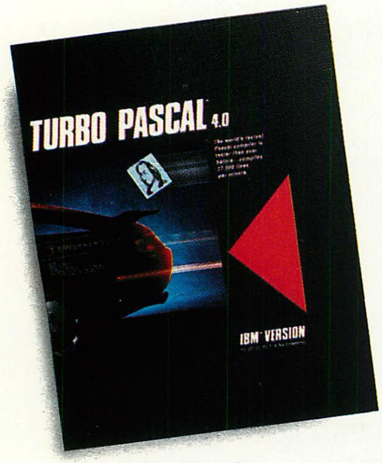

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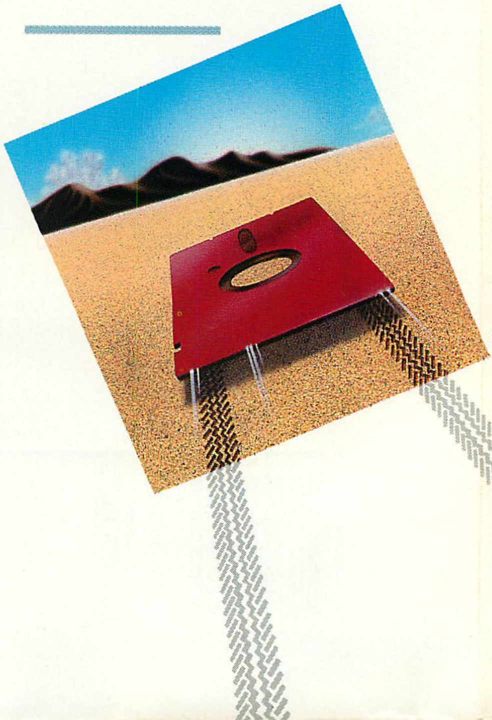

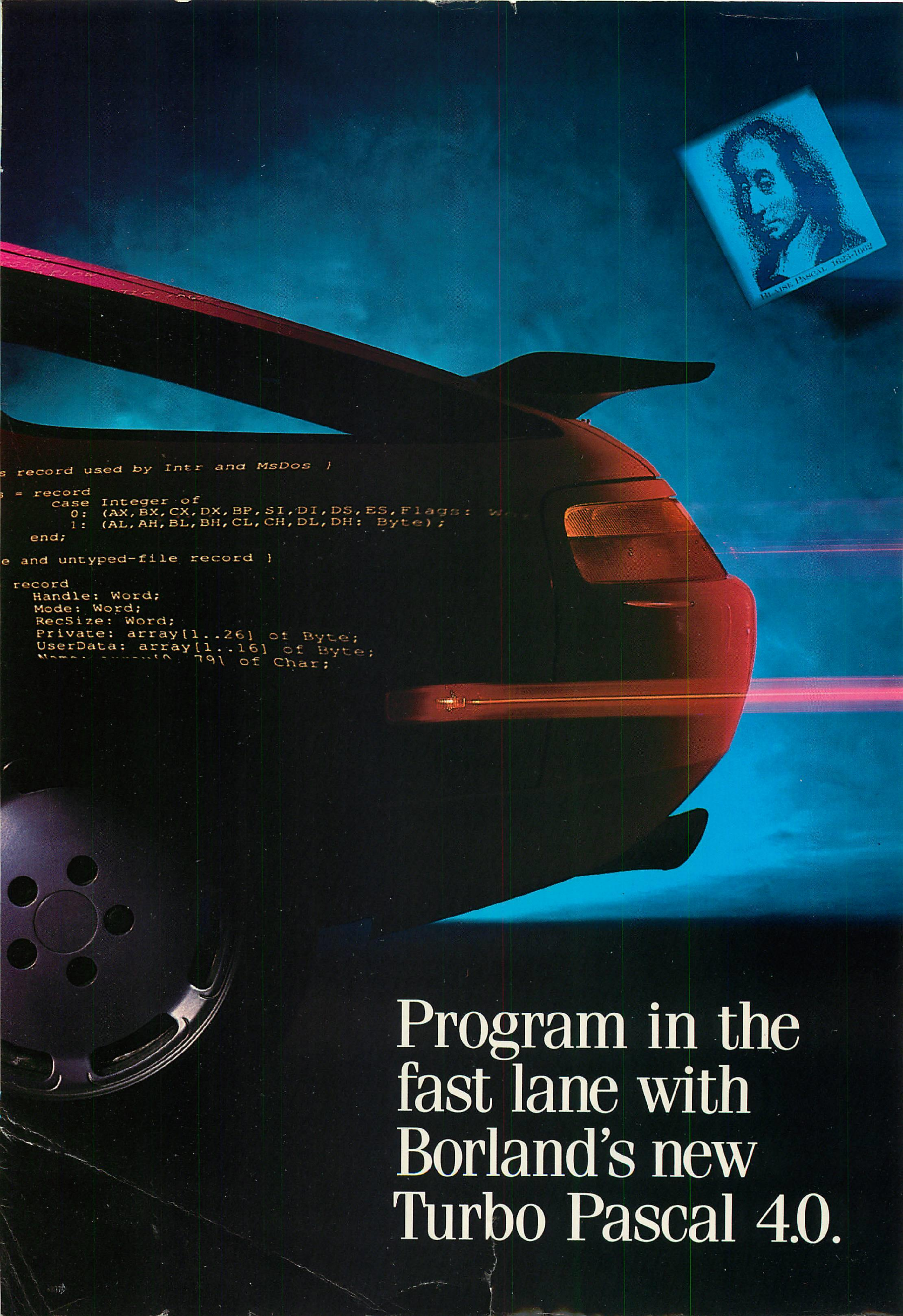

BLAISE PASCAL 1623-1662
s record used by Intr and MsDos }
s = record
case Integer of
0: (AX,BX,CX,DX,BP,SI,DI,DS,ES,Flags:
1: (AL,AH,BL,BH,CL,CH,DL,DH: Byte);
end;
e and untyped-file record }
record
Handle: Word;
Mode: Word;
RecSize: Word;
Private: array[1..26] of Byte;
UserData: array[1..16] of Byte;
79] of Char;
Program in the fast lane with Borland's new Turbo Pascal 4.0.

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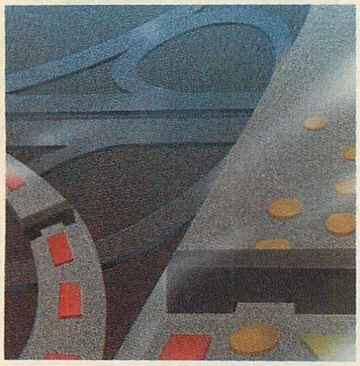
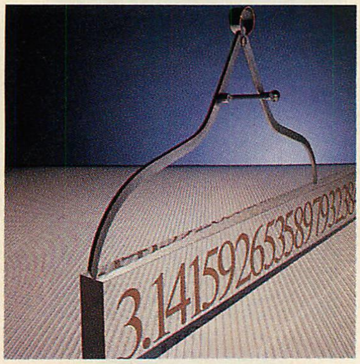
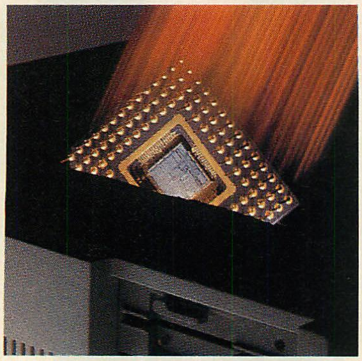




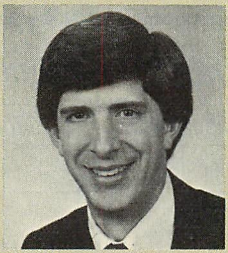


COVER SUITE: OS/2 ALTERNATIVES

The dilemma so far has been whether to stick with DOS or go with OS/2. Other viable choices may test your operating-system loyalty.

Cover illustration • Leslie Cabarga

OUTFITTING OUR COLUMNS



We welcome a new columnist to our pages this month. Peter Coffee will focus on the logistics and problems of delivering the appropriate products to the end user. Coffee brings an eclectic mix of talents to his column. He is an in-house consultant in AI applications, distributed computing, and data analysis for an aerospace firm and is managing partner for SolveWare, a software development and consulting company. In his spare time, Coffee teaches information systems management and expert systems at Pepperdine and UCLA, serves as an officer of the PC Professionals Association, and is a member of the ANSI committee for standardizing LISP. His column, Outfitting the End User, begins on page 171.

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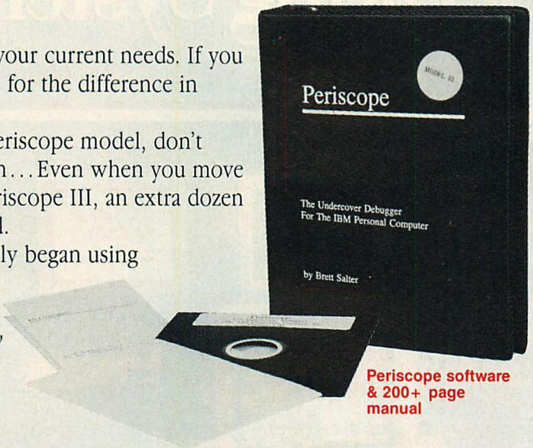

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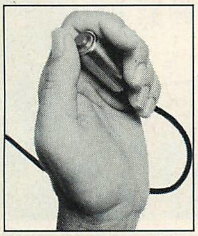
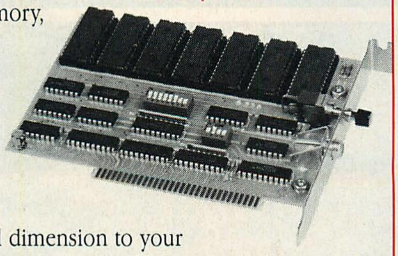


Periscope Break-Out Switch

Periscope I has a board with 56K of write-protected RAM. The Periscope software resides in this memory, safe from run-away programs. DOS memory, where debugger software would normally reside, is thus freed up for your program.



Periscope I Board

Periscope III has a board with 64K of write-protected RAM, which performs the same function as the Periscope I protected memory. AND...

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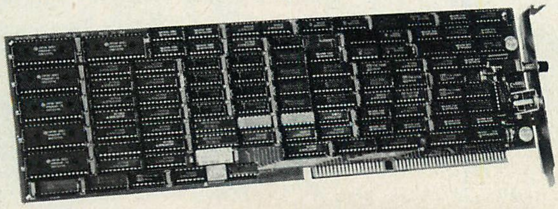

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Periscope I user

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Periscope II user

"I am very impressed with Periscope II-X ...it has become my 'heavy duty' debugger of choice, especially if I need to work on a memory resident utility or a device driver."
Periscope II-X user

". . . Periscope III is the perfect answer to the debugging needs of anyone involved in real-time programming for the PC . . . The real time trace feature has saved me many hours of heartache already."
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SYSTEMS PERSPECTIVE

Compelling Issues

The wait continues for an application that will do for OS/2 what Lotus 1-2-3 did for DOS. Until then, OS/2 will have competition.

Applications sell operating systems. Users choose the applications they need and those decisions drive the choice of operating system. In the world of desktop computing, that operating system has, without question, been DOS—until now.

Whether OS/2 can win this same level of industry acceptance is debatable. Other operating systems and environments have sprung up that have won the respect of users and developers alike, but the trouble is that no one environment seems poised to deliver all that we require. These other contenders for that crown are the subject of this month's cover suite.

Starting with "Choosing an Operating System" on page 50, we look at the features of operating systems that users and developers should consider before making their selection. In "386 Operating Environments" on page 60, we examine four possible candidates: two complete operating systems—Digital Research, Inc.'s Concurrent DOS 386 and The Software Link's PC-MOS/386—and two 80386 control programs—Quarterdeck's DESQview and Microsoft Windows/386. Finally, "The DOS-UNIX Union" on page 78 reviews Locus Computing's DOS Merge 286, which creates a hybrid DOS-UNIX environment.

In all cases, we found advantages to praise and shortcomings to disclose. None of these environments enjoys wide industry acceptance, and none offers everything a developer craves: multitasking within and between programs, interprocess communications, unrestricted execution of multiple DOS applications, and access to the 386's flat address space. But neither does OS/2.

Industry acceptance may be the most important "feature" of an operating system. How DOS attained its enviable position as the most popular operating system is a simple story that began when IBM decided to market DOS for its personal computer. IBM's backing alone does not guarantee an operating system's success—witness the commercial failure of TopView—but it does lend a high degree of credibility and respectability to a good product. (IBM also markets XENIX for the PC, but this is more suited to developing and running special-purpose vertical applications.)

More important to DOS's success were the development efforts of one brilliant team at Lotus who created what has come to be known as a *compelling application*—one that improves productivity so dramatically that it alone justifies the cost of the computer (and the operating system).

As the success of Lotus 1-2-3 grew, other developers, confident that the application, and therefore that DOS, would be found on most desktops, developed their perhaps less compelling, but still useful, applications on DOS. The symbiosis of applications and the operating system fed upon itself; as more applications were developed, more copies of DOS were sold, and more applications were developed.

The acceptance of OS/2 may not be as simple a tale to tell. It is still early, but we have yet to see that compelling application, and we may not see it for some time. To be compelling, the application must run only on OS/2—that is, it must exploit features found only on OS/2. In other words, OS/2 must be a *compelling operating system* for the *developer*.

True, OS/2 frees developers from the inadequacies of DOS, but OS/2 has its own inadequacies, tied to the inferior operating system support delivered by the 286 processor and OS/2's inability to exploit the 386. In this imperfect world, each alternative operating environment offers at least one compelling feature, but each has drawbacks, too.

With no clear winner among operating systems, developers are hedging their bets. Although many are converting to OS/2, they are not fully exploiting OS/2's features—at least not multitasking within a program, which is a perfect opportunity for performing background tasks within an application. For example, the first release of Ansa's Paradox for OS/2 has no internal multitasking. If a user wants to run a report while updating a database, Ansa recommends running a second copy of Paradox and letting *its* multiuser features manage any contention for data.

Without capitalizing on the features of OS/2, an OS/2 application is really no different than the DOS version of that application. Ansa, now

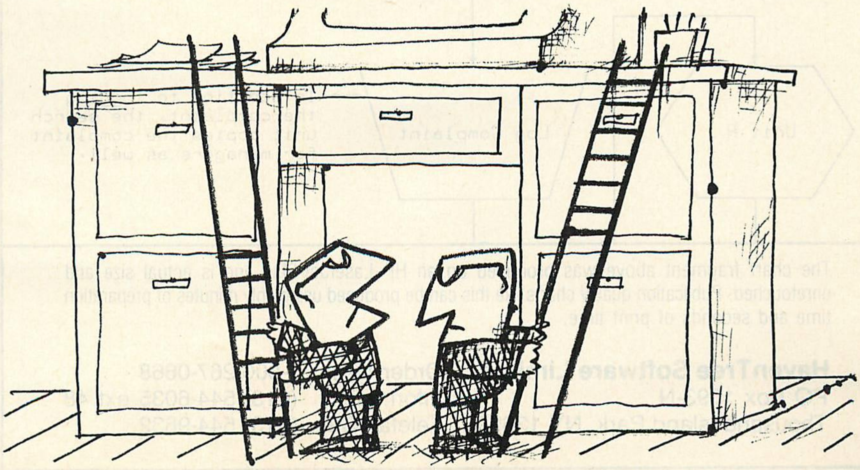

ILLUSTRATION • MACIEK ALBRECHT

owned by Borland, is developing four versions of Paradox, all with similar feature sets. Besides DOS and OS/2 versions, Paradox will run on UNIX; and Paradox/386, written with Phar Lap's DOS Extender, will run on a 386 concurrently with other DOS programs under DESQview/386. Similarly, Lotus is developing 1-2-3 release 3.0 to run on both DOS (using expanded memory) and OS/2. Both versions will deliver the same features to the end user.

Certainly, neither of these applications compels a move to OS/2. While no compelling application has yet materialized, many developers are poised and ready to follow in its wake should it appear. For now, many users may feel they want to buy a 386 machine, but stay with DOS applications.

NEW TECH FEATURES

With this issue, I am happy to release an enhanced and compelling version of *PC Tech Journal*. We have expanded one existing department and added two new features to the magazine.

Our Tech Notebook series has a new and expanded format. Technical editor Ted Mirecki will cull technical tips gathered from every conceivable resource to solve your development problems as well as to alert you to bugs and other quirks in hardware and software. We encourage you to submit any tips you may have for publication.

Peter Coffee is the author of a new column, Outfitting the End User, found on page 171, and we consider him a real find. Drawing on his years of experience as an information systems manager, Coffee will offer his lively insights into the challenges and frustrations of delivering workstations and applications to the end user.

We received such a good response from our June 1987 ballot card on the Macintosh that we are making these reader opinion cards a regular feature. Each month we will ask for your opinion about a hot topic—this month it is about your acceptance of OS/2. We want to know what you think about all the thorny issues that you face daily as a systems professional. We will subsequently report on your replies in a department to be inaugurated as soon as we collect the responses. This way, you can learn what your fellow readers are thinking, too. Please fill out the card, bound in front of this editorial, and return it to us promptly; we are anxious to hear from you.

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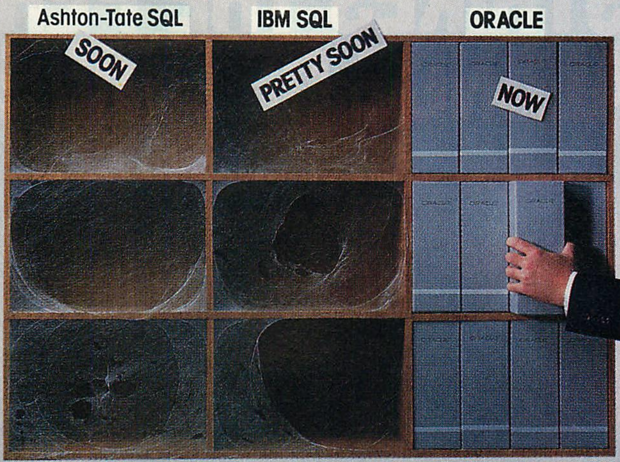

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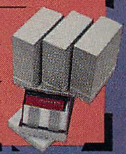

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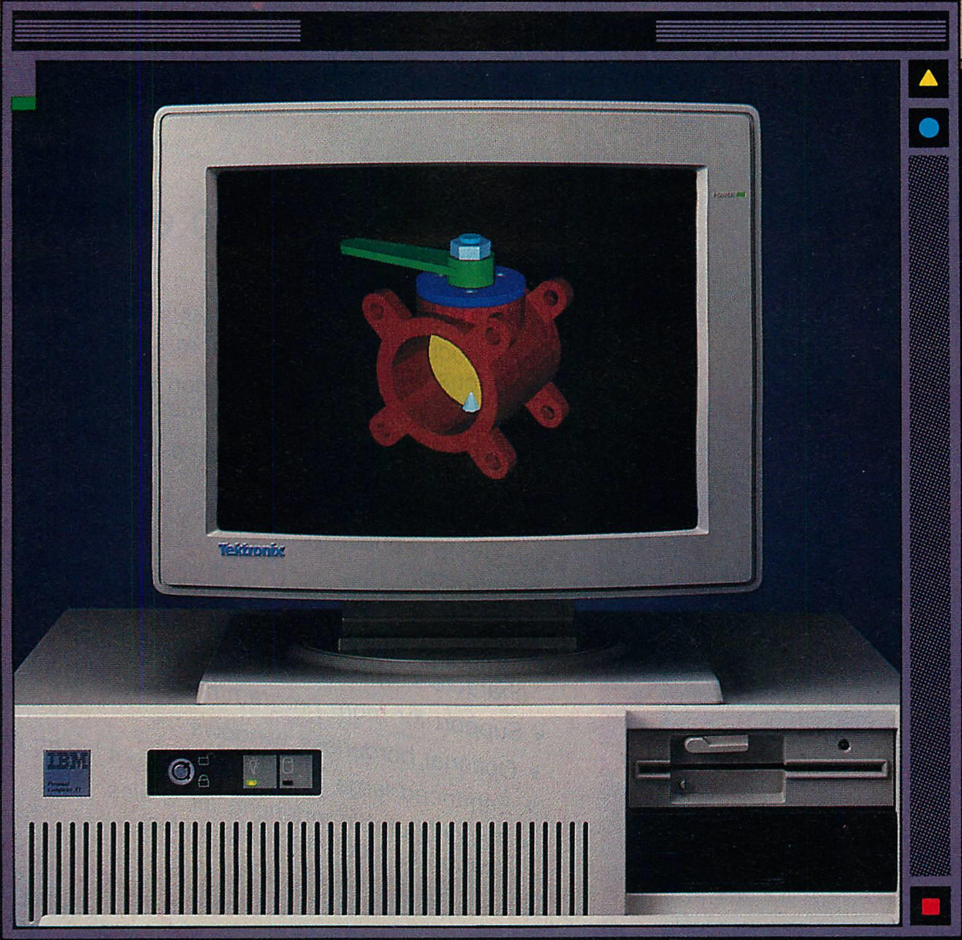

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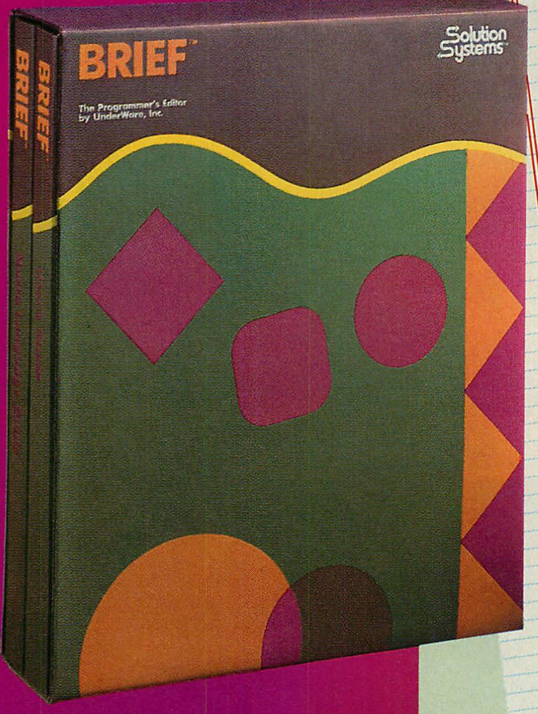

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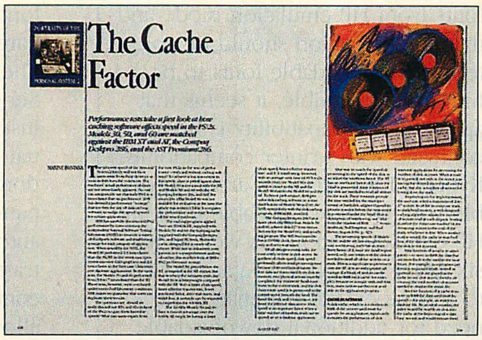

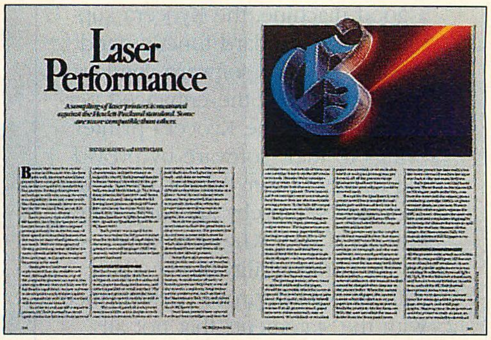

A HIDDEN CACHE

"The Cache Factor," by Maxine Fontana in the August 1987 issue of *PC Tech Journal* (p. 168) gives a good idea of the improvements in execution time that may be practically realized using disk cache software. However, since many nondisk operations are included in these time figures, it is a difficult task to isolate the cache factor from the choice of the task factor.

Elsewhere in the August issue, articles on the PS/2 Models 50, 60, and 80 give a better idea of how much cache improves disk access time independently of other program operations. The time values lump the write and read times together and do not show that, in most cases, improved performance is almost always due to reduced read times. Tests also did not include times for a second read that, with large cache, matches those of a RAM disk.

Times (in seconds) for first and second reads for the Models 50 and 60 and the 8-MHz AT are given below for small and large cache. Extended memory was used for each test to eliminate memory access variables. The default page size (4 sectors) was used on IBMCACHE.SYS.

- Model 50: first read, 4.73 (small and large cache); second read, 4.78 (small cache) and 1.43 (large cache).
- Model 60: first read, 3.02 (small cache) and 3.13 (large cache); second read, 3.08 (small cache) and 1.43 (large cache).
- 8-MHz AT: first read, 4.05 (small cache) and 4.01 (large cache); second read, 4.06 (small cache) and 1.93 (large cache).

Times were computed by reading the system clock before and after performing the desired file operation. Since the clock has a resolution of about 0.055 seconds, differences in the second decimal place probably are not significant. I define a small cache as any size smaller than the file size (256KB) and a large cache as the size to give a second read time that is roughly equivalent to the read time of a RAM disk. The minimum size that is required to get reduced second reads with the IBM driver is somewhere between 256KB and 320KB.

Fontana also did not mention features of Compaq cache, such as reporting of read/write statistics, support for expanded memory, and turning the cache on and off without system reboot. This on/off feature is particularly important when using software such as FoxBASE+ (version 2.0), which has its own built-in disk caching routine. Running FoxBASE+ with the system disk cache turned on can cause lost clusters and other file problems.

IBMCACHE.SYS seems to run alright on Compaq PCs. When I tried running FoxBASE+ on an 8-MHz AT with the Compaq cache installed, file clusters were lost even when the cache was turned off. No doubt, many copies of the IBM and Compaq caches will be circulated in the underground economy. IBM supports only its cache software for operation on the PS/2 Models 50, 60, and 80, and Compaq follows suit for cache operation on its 286 and 386 PCs. The price that one pays for not buying a reliable, supported, third-party cache program for a clone may be realizing all too late that an unauthorized copy of the IBM or the Compaq cache driver unfortunately has completely ruined valuable files.

David L. Spooner
Wilmington, DE

The purpose of "Cache Factor" was not to evaluate specific cache features nor to examine the effect of a cache in a controlled read/write environment. We also did not want to promote running the IBM cache or Compaq cache on any machine other than those for which they were designed, since problems such as those described by Mr. Spooner with FoxBASE+ could possibly result. The thrust of this article was to compare the performance of PS/2 (with supplied cache) with that of other machines with cache added in real-world applications. However, the article could have benefited from testing a wider variety of software such as CAD/CAM, statistics, and expert systems as well as from the write/read tests that Mr. Spooner describes, particularly for demonstrating the effect of cache on second reads when a large cache is employed. In fact, Mr. Spooner's results give further support to our findings that the 8-MHz AT with cache added often can outperform the PS/2 Model 50.

—MF

PERFORMANCE BLUES

As a an avid reader of *PC Tech Journal*, I normally look forward to receiving your publication. This is not the case with the September 1987 issue. I was very disappointed when I read your article, "Laser Performance," Rainer McCown and Heeth Clark (p. 100). My disappointment is not only in your review of Kyocera's F-2010, but of the other printers as well. I had come to believe your reviews were providing valuable information to the public. However, the information in "Laser Performance," not only contains incorrect, inconsistent, and conflicting statements, but shows an uninformed bias towards one printer supplier.

Some of the items that Kyocera Unison takes exception to are listed below. This is by no means a complete list but should serve to inform you of some of the problems that we have with your article.

1. The article stated that, as software is developed for new capabilities, compatibility with the HP standard will become a more critical factor. Software capability *is* the overriding factor in utilizing laser printer capabilities. Although the HP laser is

a good machine, the Kyocera supplies more standard function and capability. Major software vendors have recognized the enhanced performance that the Kyocera printer brings to their software by providing Kyocera Laser Printer Drivers to their users, thereby allowing fully functional use. Why should you settle for compatibility alone when you also can improve performance?

2. With the statements that not all laser printers can use cartridge fonts from HP emulation mode and that an application should be able to use downloadable fonts to be fully HP compatible, it seems that application compatibility is being confused with printer compatibility. Kyocera Laser Printers are compatible with HP downloadable fonts in HP emulation mode as well as in six other emulations. Kyocera has, to a large extent, eliminated the need for additional downloadable fonts by building in 36 resident fonts and 4 dynamic fonts as standard features for its printer.
3. The article noted that in the HP Series II the user needed only to insert a single sheet into the manual feeder. This operation was done independently of the control panel and took precedence over automatic feed. Kyocera, by contrast, provides more flexibility and control over printing functions by allowing the user to select the input source manually from the control panel or directly from the keyboard. Many laser-printer users, especially network or shared users, prefer to leave an envelope in the manual tray at all times so that a command need only be issued from the software to invoke manual feed. The fact that we are offering choices to the users of our printer constitutes a very significant part of user satisfaction.
4. The article added that other printers such as the Kyocera F-2010 are more restrictive, in that the F-2010's input-tray selection cannot be changed when data are in the print buffer; thus when the tray runs out of paper, the other tray cannot be selected nor can paper be put into the manual port. This incorrect statement is reiterated later in the article. To finish a print job when the current tray runs out of paper, the operator need only select another tray from the front control panel or the keyboard.
5. You noted that separating the drum and toner did not greatly reduce costs and complicated shipping due to possible toner spillage. Dataquest cost factor studies show that Kyocera is one of the lowest-cost-per-page laser printers. This is accomplished by separating the toner and the drum. By separating the toner and drum, the maximum use of each component is possible. Kyocera printers are not shipped with the toner, developer, or drum in the machine; thus chances for toner to spill are nonexistent.
6. The timing results in table 1 of your article show that the HP Series II's time to print a full-page random dot metric was 134 seconds, compared with the 98 seconds it took the Kyocera F-2010 to perform the same task, which is 26.8% faster than the Series II. The results appearing in the table clearly conflict with your report that the Series II was the fastest

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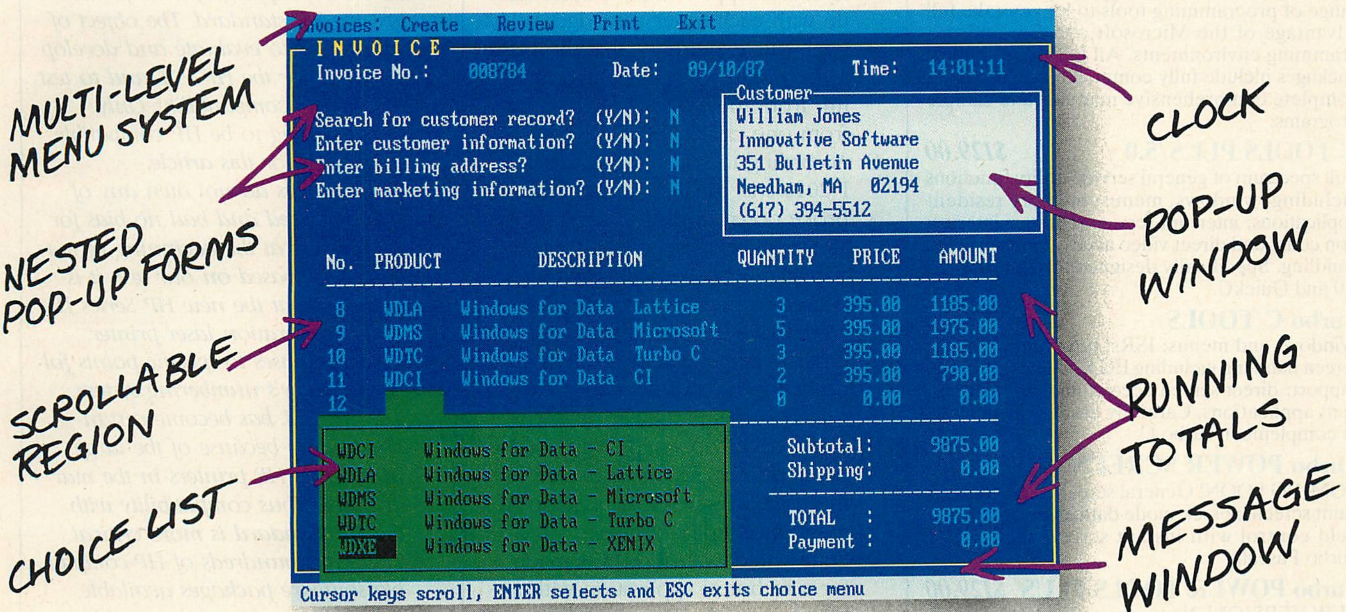

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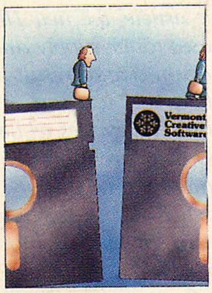

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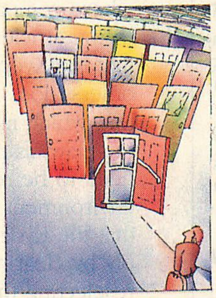

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printer in many of the metrics and faster than all of the other printers on the full-page graphics test.

7. Further, you stated that, unlike the other printers, the F-2010 waste toner bottle was nearly filled, causing concern about possible spillage. Kyocera supplies a new waste bottle with each toner cartridge. It has been our experience that the waste toner bottle will not be even half-full from the waste toner coming from one cartridge.
8. According to your article, the F-2010 was the only printer that broke down during testing and that after repair, it broke down again. You state that the problem appeared to be a loose cable and could have happened to any of the other printers. If the problem appeared to be a cable, which cable was it? If this particular problem could have happened to any of the other printers, possibly caused by the user, why was this breakdown mentioned in the article?
9. Your stated evaluation was made for a technical application with a bias toward desktop publishing and limited to printers that provide HP emulation, which is of "paramount importance to sophisticated users." Why is HP emulation of paramount importance? Kyocera supplies seven emulations to increase the flexibility and compatibility of its printers to the benefit of its customers. Does HP supply this? Kyocera is compatible with every major desktop publishing package, which is where compatibility counts.
10. In the article, mention was made that the Kyocera printer, among others, does not have a reset button, which fact is considered a serious flaw, as printers frequently need to be reset in a development environment. In rejoinder, we state that the Kyocera can be reset simply by clearing the print buffer and reselecting the desired emulation. The emulation can be selected from the control panel or the keyboard. The print buffer is cleared by pressing the cancel button that is located on the control panel.

I understood the intent of the article was to measure how well the lasers performed your metrics; yet, the results of all the tests were not clearly reported. It appears that the F-2010 passed all the metrics and gave results that were the same as or better than the other machines tested, with the exception of the complexity metric that the HP Series II also failed.

Larry Heltsley
Kyocera Unison, Inc.
Berkeley, CA

As the subtitle to the article states, we measured a sampling of laser printers against the HP standard. The object of the article was to evaluate and develop laser metrics for the HP PCL and to test HP LaserJet + compatibility. Only printers claiming to be HP compatible were reviewed for this article.

The authors do not own any of the printers tested and had no bias for the HP printers at the beginning of testing. However, based on our test, it is our opinion that the new HP Series II is the next-generation laser printer.

Our responses to specific points follow Mr. Heltsley's numbering system.

1. *The HP PCL has become a standard partly because of the large number of HP printers in the marketplace. Thus compatibility with the HP standard is more critical. There are hundreds of HP-compatible software packages available.*
2. *All of the Kyocera fonts could not be used in HP mode, which was the only thing being tested. The article did not test font cartridges because the HP cartridges are proprietary, and the actual shape or spacing of the font characters varies from one printer to the other.*
3. *The Kyocera method of requiring interaction to switch to the manual feeder is better for networking.*
4. *With the Kyocera printer tested, the input tray could not be changed when data were in the print buffer. To finish the print job when the current paper tray ran out of paper, that tray had to be reloaded.*
5. *As stated in the article, the new HP Series II increases toner supply and decreases the drum size to result in a matching life span. Most cost studies compare retail prices while the cartridge systems are more heavily discounted than the less popular refills. It is not in shipping the printer but in shipping or moving the printer within the office environment after toner has been installed that the loose toner does become a problem.*
6. *The Kyocera printer was indeed faster than the Series II in the full-page random dot metric.*
7. *The Kyocera [printer] tested wasted much more toner than any other printer evaluated. We pointed out*

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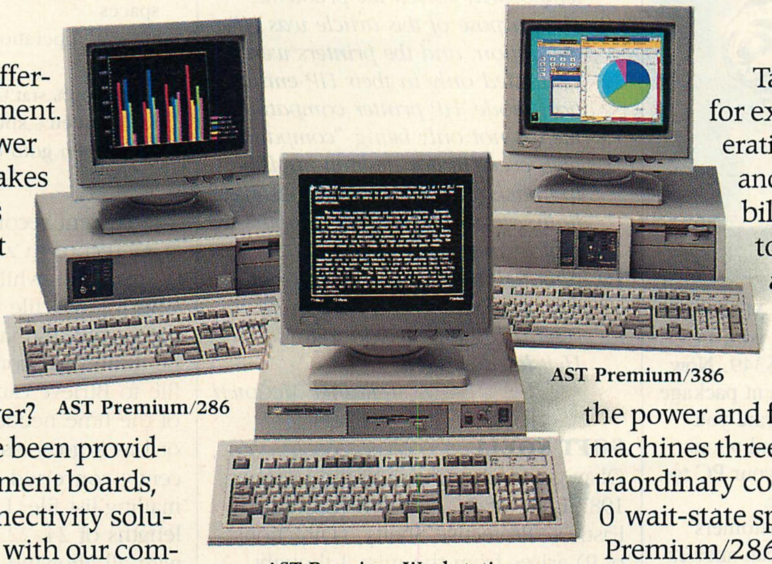

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this waste to remind Kyocera owners that the waste bottle must be replaced each time that the toner supply is refilled. Note that this toner waste increases printer costs.

8. *The fact that this printer broke down a couple of times in testing may be why there is a conflict between our findings and Mr. Heltsley's. Or he may be testing a newer model. The Kyocera repair person adjusted the machine, which temporarily solved the problem.*
9. *The purpose of this article was HP emulation, and the printers were evaluated only in their HP emulation mode. HP printer compatibility means not only being "compatible with every major desktop publishing package" but also with essentially all printer programs, both major and minor.*
10. *Although there is not a reset button, the Kyocera printer can be reset using the method that Mr. Heltsley described.*

—Rainer McCown

SOFT SHELL

Okay guys, what gives? In the October 1987 issue of *PC Tech Journal*, Will Fastie's "Protective Shells" (Directions, p. 9) arises from the mist. I thought this was *PC TECH Journal*, Tech (I always thought) meant *technical*. If I want DOS shells, I'll read one of the many computer rags that are meant for shell lovers only.

I've always counted on your well-written technical information to guide me through foggy interrupts and complex architecture. Let's not revert to a LOW-END magazine. Which "camp" do you *really* belong to? "To DOS Shell" or "Not to DOS Shell"—that is the question I put forth.

Adriene L. Nazaretian
Yale University
New Haven, CT

"Real programmers don't use shells?" Maybe not. But real programmers do deploy systems and applications to the desktops of end users, who can benefit greatly from the simplicity a shell affords. Therefore, real programmers need to know about such things just as much as they need to know about the system internals.

—WF

TIME TO BTRIEVE

As a programmer using Btrieve for several years, I was pleased to see Burks A. Smith's fine article ("A Data Manager with Language Flexibility," p. 104) in the October 1987 issue of *PC Tech Journal*. However, I would like to add two of my comments.

First, regarding partial key searches, the following QuickBASIC code fragment shows how I handle this particular problem:

```
kbuf$ = space$(7) ' assuming key is state +
    zip
part$ = "CA" ' partial key
lset kbuf$ = part$ ' fills rest of kbuf$ with
    spaces
op% = 9 ' operation 9 is "get greater or
    equal"
call btrv(op%,stat%,
    fcb%,buflen%,kbuf$,knbr% ) ' call Btrieve
if stat% then goto error.routine ' check
    status
```

The current record is now the first "CA" record in zip order.

Second, while defining several keys for one file avoids having to sort the second file later, developers should be aware that converting an existing file to Btrieve can take hours because of the time needed to index each record as it goes. As an example, I recently converted a 100,000+ name, mailing-list file. I defined six keys with lengths of 24, 22, 10, 12, 9, and 10, with all allowing duplicates. Using a 10-MHz 286 machine with a 60MB hard disk, the file conversion took more than 50 hours to complete.

Fortunately, this needs be done only once. The normal one second or so for storing each record during keyboard data entry is acceptable, considering that the file never has to be sorted. In the mailing-list file described here, I can look up a record by name, zip, address, or phone number in less than one second.

Brad Smith
Tulsa, OK

You are indeed correct about the partial key search. The appropriate use of "get greater or equal" must have somehow escaped me.

The value of defining several keys for one file is well illustrated by your example, since the long indexing times you report in converting an existing file would also be encountered in producing an ad hoc index later. If a file is to be built from scratch through keyboard entry, the one second per record overhead is more palatable than a 100,000-second indexing job.

While the graphs that accompanied the review indicate that Btrieve performs well when compared with the

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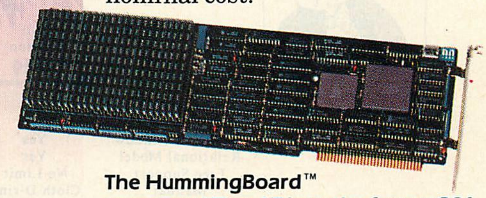

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"average" product tested by PC Tech Journal, *it should be noted that its indexing times are not impressive when they are compared to the most popular database products.*

—Burks A. Smith

BOOLEAN FUNCTIONS

I'd like to comment on the letter, "Missing Links" (see Letters, September 1987, p. 15) that appeared in *PC Tech Journal*. The letter was correct in most respects. One minor correction deserves to be made, however, regarding external Boolean functions.

The letter states that external functions should not return a Boolean value by setting the Z flag, because Turbo Pascal ignores the flag. Actually, Turbo Pascal handles the results of external Boolean functions in two separate ways, depending on the use of the function. If the function is employed in an IF statement, then a JNZ (or JZ) is generated immediately following the call to the external function. On the other hand, if the function is employed within an assignment statement, then AL is used. The well-behaved external Boolean function will thus return a 0 or 1 in AL and will also set the Z flag.

I hope that this clarification helps. (You have an excellent magazine. Keep up the good work!)

R.C. Wyckoff
Big Bear City, CA

Thank you for the clarification. The confusion came from inspecting code that used only the Z flag or the AL value, because in most situations both uses of a function are not coded together. A Boolean function should definitely return its value both in the flag and in the register so that it can work in either of these situations. *—DM*

COMMENTS WELCOME

All letters to the editor should be directed to Editor, *PC Tech Journal*, Suite 800, 10480 Little Patuxent Parkway, Columbia, MD 21044. Correspondence also can be submitted over MCI Mail to PCTECH.

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microsoft products

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for XENIX	995	CALL
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Microsoft Pascal Compiler	300	CALL
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MKS RCS *Revision Control System*	189	155
MKS Toolkit *with MKS VI Editor*	139	109
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MKS VI *Editor by MKS*	75	65

modula-2 language

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Macro2 *Macro preprocessor by PMI*	89	79
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mouse products

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with PLUS & First Publisher	CALL	CALL
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Microsoft Mouse *See Microsoft Section*		

other languages

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other products

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polytron products

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program mgmt utilities

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TDebugPLUS *by TurboPower Software*	60	49
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Universal Graphics Library *by Quinn-Curtis*	130	119

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DIRECTORY SHELL 286 *by American Mgmt Sys*	349	295
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Epsilon *Text Editor by Lugaru* *New*	195	147
Micro Focus Products *See Micro Focus Section*		
Microport Products *See Microport Section*		
Microsoft Products *See Microsoft Section*		
PANEL Plus *by Roundhill Computer Systems*	795	535
REAL-TOOLS *Binary Version by PCT*	99	89
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RM/COBOL *by Ryan-McFarland*	1250	949
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SCO Products *See SCO Section*		

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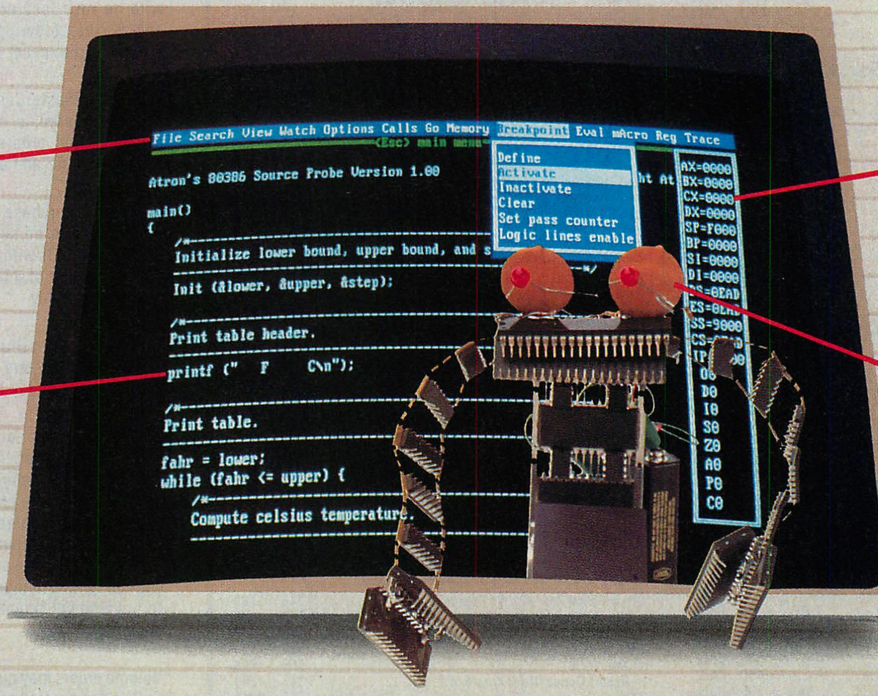

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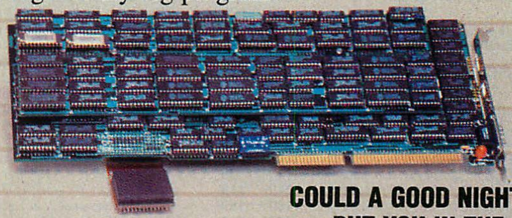

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The Industry's Pulse

386 fervor, IBM excitement, and EMS 4.0 all beat strongly at COMDEX.

Barely a week after leaving Las Vegas, COMDEX/Fall is little more than a blur. That might mean I spent three days in a frenzy of new products. It might mean I spent too much time on the evening party circuit ("press always welcome"). It might mean I just couldn't see for all the rain. Or it might mean I am still in a rage about hotel rooms and cars (Las Vegas does not love our conventions).

None of the above is the correct answer. The trade press has already reported a "dearth" of new product introductions at this annual gathering in Las Vegas. From my perspective, however, the hot news is not new products, but the general health of the computer industry. We need to check the industry's pulse, both to find out if it is healthy and to make sure *PC Tech Journal* is following the right issues and watching the right developments. Looking for the pulse kept me busier at this COMDEX than at any trade show in recent memory.

Even without lots of product announcements, this was an exciting (and fun-filled) COMDEX. Here are some observations about what I found, as well as a look at a few products.

THE 386 MOMENTUM

No one could seriously doubt the strengthening penchant for the 80386 and all it implies. What I found remarkable, however, was just how strong the momentum really is.

Intel made an effort to get this point across by hosting a well-attended afternoon session during which industry leaders touted the 386 and the advance of technology it represents. Fortunately for Intel, the success of 386-based products will not be based upon what was a rather boring and even downbeat session and a rather lackluster demonstration room, which had none of the excitement of last year's exhibits. Intel is absolutely in the driver's seat and should show it off with a bit more pizzazz.

Nonetheless, David House, Intel's senior vice president and general manager of the Microcomputer Components Group, provided good information about the progress of the 386. For example, Intel will have four fabrication facilities online and producing the chip by the end of the first quarter of 1988. This is twice as many as for the 80286; the annual production of chips in the 386's second year will be twice the level of the 286 in its second year.

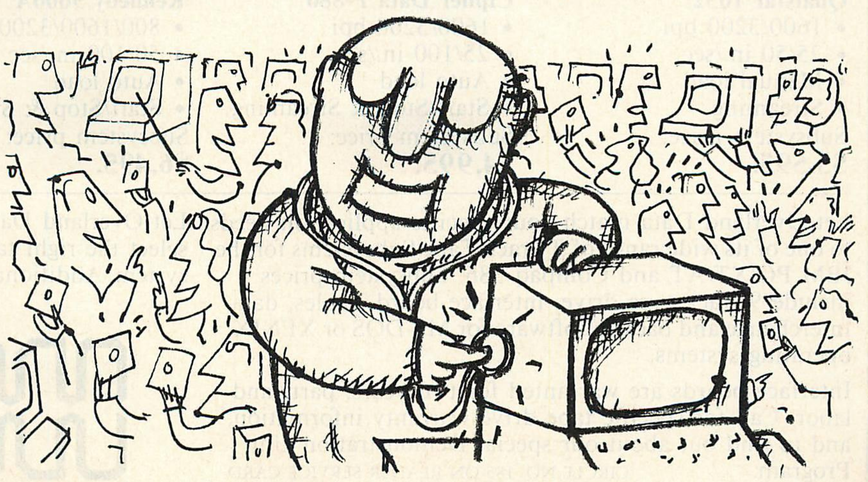
Better yet for Intel, demand for the 386 is staggering. House owned up to early delivery problems, but pointed out that Intel could have gotten back on track in a quarter or two if only demand had stayed at the original projections. It is a nice problem to have: demand for the chip has so outpaced supply that House's chart still showed a shortfall by the end of 1987. Intel now seems to be catching up, however, and claims to be ahead of previously stated production schedules as a result of a faster ramp-up to meet the unexpectedly strong demand.

According to House, the 386 is a processor architecture that spans the entire spectrum of computing, from the home to the data center. In the middle, the 386's current stomping ground of high-performance desktops, Intel is now able to offer 20-MHz chips supported by 20-MHz 80387 math coprocessors, 20-MHz 82385 cache controllers, and the 82786 graphics chip.

House called 1989 "the year of the 25-MHz 386" (the rumored 24-MHz version is thus officially dead). He also said that Intel would provide a version of the chip that would allow vendors to build 386-based computers costing less than $1,000 at retail, although he did not elaborate with timeframes or other details of such a processor.

Finally, the much-rumored 80486 processor should be available in 1990, House said. He defined it as 100-percent binary-compatible with the 386 family that runs two to three times faster. That the chip represents a challenge for Intel is clear; House said the 486 will require 1 million transistors on the silicon—that's three times more than the 386 of today.

Intel is being refreshingly open about its manufacturing problems and plans for the future. Knowing that the company soon will overcome the supply problem, and that it intends to expand its 386 family, is very helpful to the industry. We now know that we can plan for deployment of 386-based desk-



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tops because availability should be good. We also know that as supply grows stronger, prices will fall, making 386 systems more attractive. Best of all, we know that Intel is committed to a strong future for its current flagship product. That's good for everyone.

Now, if we only knew about the "80388" (my code name for a 16-bit version of the 386 that can replace the 80286 in its socket); I would really like Intel to tell us once and for all whether it will offer such a retrofit product. As I have said so often before, all of us who have purchased 286-based systems have been left at the altar; we never got a chance to fully exploit the 286 before the 386 generation began. The 80388 would be a relatively low-cost way to add some life to all that 286 iron out there.

386 ON THE FLOOR

Excitement over the 386 was evident all over the exhibit halls, but Intel may have been the star with the announcement of its Personal Computer Enhancement Operation's (PCEO) Inboard 386/PC for PC- and XT-class machines. Although PCEO is not the first vendor to offer such a product, it is being extremely aggressive with the price. At an incredible list price of $995, the Inboard 386/PC with 1MB of RAM is on a par with many 286 add-in boards. Microsoft's Mach 20 with 1MB of RAM, for example, lists for $880; the extra $115 for the Inboard buys compatibility with all the emerging software that can exploit the 386. Memory can be expanded to 3MB; the optional piggyback memory board lists for $645 for 1MB and $1,145 for 2MB. The product includes a driver for version 4.0 of the Expanded Memory Specification (EMS) and disk-caching software.

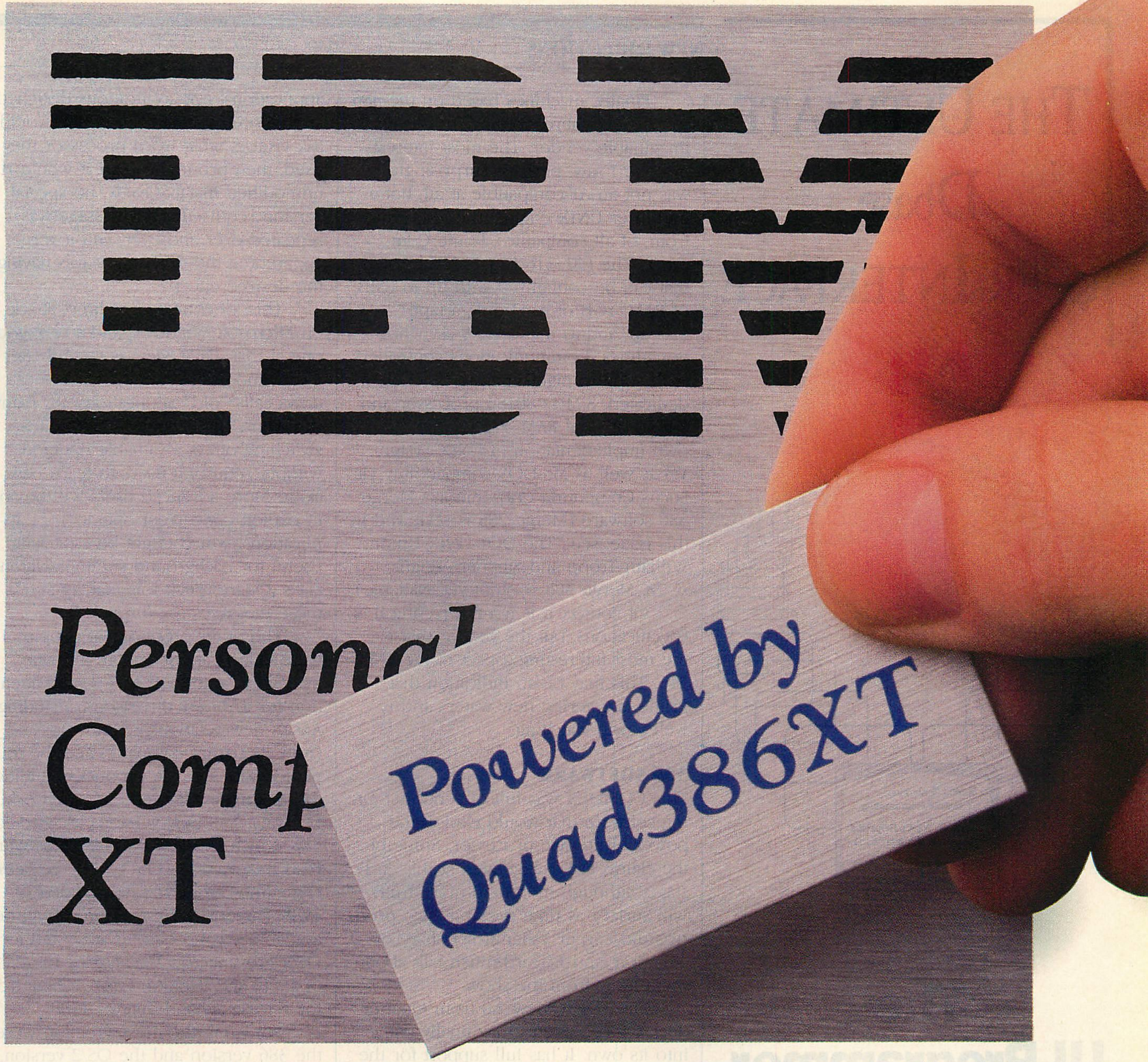
PCEO also reduced the price of the original Inboard 386 for the AT to $1,595 with no memory (previously $1,995) and $1,895 with 1MB of RAM (previously $2,495). This reduction makes the InBoard 386/AT more competitive with the rest of the market and surely is long overdue.

The Inboard 386 is now compatible with a wider variety of 286-based systems, including Tandy 3000, Wyse 286, and Compaq Deskpro 286 systems (except for the 12-MHz version). The buyer must specify which machine will be upgraded because $200 of the list price goes for a machine-specific installation kit. As with the Inboard 386/PC, the original Inboard includes software for EMS 4.0 as well as the new disk-caching program.

I do find the Inboard pricing ironic. The Inboard 386/PC improves performance of an XT by a factor of about ten, making it twice as fast as an AT. The more expensive Inboard 386/AT accelerates an AT by a factor of three, or one-third the boost given an XT, and yields a system with 50-percent better performance than the accelerated XT.

Intel was not the only vendor getting 386 attention. Compaq certainly garnered its share of traffic with its new offerings, the Deskpro 386/20 and the Portable 386. As predicted, AST Research was showing not only its Premium 386 machine but also the 386 add-in board for the Premium 286. Called the FASTboard/386, it lists for $1,995. *PC Tech Journal* has yet to examine this product, but if it measures up in our compatibility studies, it becomes a strong buying incentive for the Premium 286 system.

IBM did not particularly play up the PS/2 Model 80s, although it did give one away, and several were present in the booth. Model 80s do seem to be flowing in the distribution channels, however, so IBM is now anted up and ready to play.



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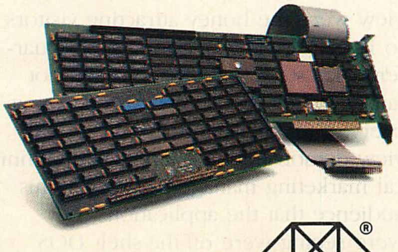

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Finally, machines based on the 386 were everywhere, coming from every imaginable vendor. The most interesting one I saw, perhaps surprisingly, was not an AT-compatible at all, but a multiuser UNIX engine: the EXL 316 from, of all companies, Prime Computer. The EXL 316 is a 16-MHz system that can be configured with up to 8MB of RAM, 1GB of hard disk, a tape backup, and as many as 58 asynchronous lines. Communications controllers each support eight lines and include a dedicated, 8-MHz 80186 processor and 128KB of local RAM. Prime offers its own implementation of UNIX System V.3 as well as MS-DOS compatibility via Locus Computing Corporation's Merge 386 software (Merge 286 is reviewed in this issue; see "The DOS-UNIX Union," William Tropp and Stephen Wright, p. 78. Merge 386 was not yet available).

Of course, it is not the technical specifications, but the vendor that is the most interesting aspect of the EXL 316. This may be an indication that Prime is entering new waters and is well worth watching.

386 SOFTWARE

This COMDEX was full of vendors touting software that would exploit the power of the 386 processor. Some of the claims are exaggerated at this early stage, although more and more truth will surface as time goes on. Two products did corner a significant share of attention, and I heard much talk about them away from the show.

First, DESQview 2.0 from Quarterdeck Office Systems may finally come into its own. It has full support for the 386's virtual 8086 mode, so now each application can have most of a 640KB space to itself; Quarterdeck claims to have been the first environment to support their virtual mode.

Quarterdeck also announced DESQview/386, which supports not only the virtual mode but also the protected mode of the 386 processor. DESQview/386 also incorporates support for Phar Lap's new 386/DOS-Extender, which allows 386 protected-mode applications to run under DOS.

If the 386 capabilities of DESQview were the honey attracting visitors to its out-of-the-way booth, then Quarterdeck's strident message could not fail to be felt and remembered. About every other minute during his DESQview demonstration, Gary Saxer, technical marketing manager, reminded his audience that the applications they were seeing were off-the-shelf DOS applications, not applications designed and tailored for DESQview. He would ask visitors what word processor they used, then pronounce that it would run unmodified in DESQview, no special version required. This message was repeated over and over, and it was apparent at the time that it was having the desired effect.

This, of course, is a direct attack on Microsoft Windows, and a very good one at that. DESQview is much better than Windows at running what Windows calls "old" applications; for many situations, DESQview's rapid context switching offers a valuable upgrade without requiring users to learn new skills. More advanced users will be able to exploit concurrent operation of applications, which might be especially useful for background communications tasks. Quarterdeck was making sure these messages got through.

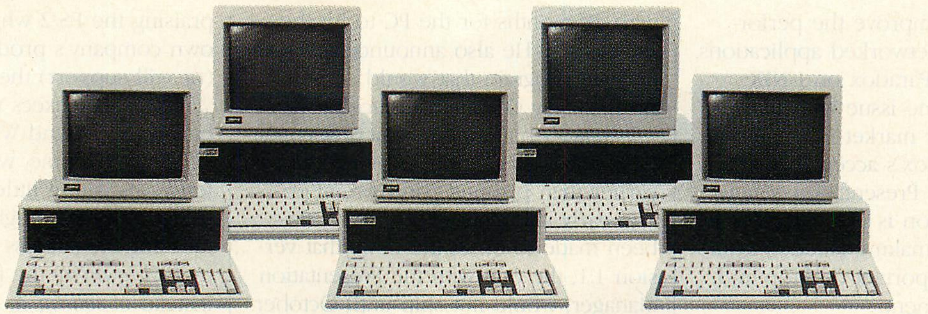
The other product that people were talking about was Ansa's data manager, Paradox. It was getting attention for a variety of reasons, including Ansa's new relationship with Borland (now its parent company) and the four new versions of the product in addition to 1.1 (single user) and 2.0 (network version). The new versions are Paradox 386, which should be available as you read this; Paradox OS/2, to be released sometime during the first quarter of 1988; Paradox Windows, which will be available second quarter 1988 and for OS/2 Presentation Manager by the end of 1988; and Paradox UNIX, scheduled for release second quarter 1988.

Attracting the most attention were the 386 version and the OS/2 version, which was being demonstrated in Borland's booth. The OS/2 demo had Paradox generating data while Borland's Quattro graphed the same data; the programs were running concurrently.

Paradox 386 exploits the 386 processor for better performance and should be very appealing to those in need of immediate raw power. The OS/2 version of Paradox should deliver similar power, especially on 386 machines, but the advantage of Paradox 386 is that it can be deployed on a 386 running DOS now, today.

The spread of Paradox to other environments elevates this product to a much higher position. The OS/2 version is especially interesting in light of IBM's announcement of a LAN server product for OS/2 (see below); this means that OS/2 versions of data managers will have the ability to run data management code at the server, which

VM/386



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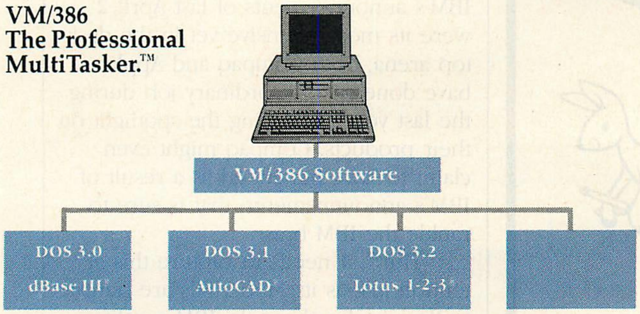
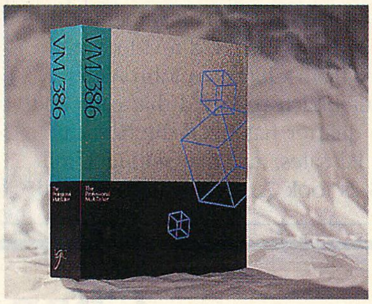
The Professional MultiTasker.™



There is virtually no limit to the number, or kind, of applications that can run simultaneously. For example, you can recalculate a 1-2-3® spreadsheet, sort a dBASE III® file, and receive your E-mail—all at the same time. You can even run more than one AutoCAD™ program simultaneously. And EGA applications run in the background as well as in the foreground—perfectly.

VM/386 protects your investment in software—and hardware. VM/386 will run all DOS software. Existing and future. Without modification. VM/386 is compatible with 80386-based PCs—either native or Intel® Inboard 386.™ VM/386 will support the monitors, hard disks, printers, mice, modems—even the network—you're currently using—or plan to use.



With VM/386 you use familiar commands. You don't have to buy new software or upgrades to get true multitasking. No PIF files. No special loaders. VM/386 works the way you do. Only lots faster.

VM/386 is easy to install. Easy to learn. And easy to use.

Dramatically increase your productivity. Start using all the power built into your 80386. Phone or write today.

IGC
4800 Great America Parkway
Santa Clara, California 95054
(408) 986-8373

System Requirements

80386-based computer such as COMPAQ® DESKPRO® 386® or 80286 computer with Intel® Inboard™ 386

One 1.2 Mb (5¼") disk drive or, one 3½" microfloppy

One hard disk drive

DOS 3.0 or later

2 Mb memory recommended

Not copy protected

Package includes both 5¼" and 3½" media.

VM/386 is a trademark of IGC.
AutoCAD is a trademark of Autodesk Inc.
COMPAQ and COMPAQ DESKPRO 386 are registered trademarks of Compaq Computer Corporation.
dBASE III is a registered trademark of Ashton-Tate Corporation.
Intel is a registered trademark of Intel Corporation.
Inboard is a trademark of Intel Corporation.
1-2-3 is a registered trademark of Lotus Development Corporation.

CIRCLE NO. 257 ON READER SERVICE CARD

IGC

can appreciably improve the performance of some networked applications. The presence of Paradox on UNIX speaks to that same issue with the traditional multiuser market in mind. Finally, given Paradox's acceptance of Windows and the Presentation Manager, a Macintosh version is not hard to envision either, thus making Paradox available for every important desktop and network environment.

IBM: STIRRING THE POT

IBM went to some trouble to whip up a little excitement. It surprised everyone not only by announcing how many PS/2 machines it had sold but also by making a splendid splash as it did so.

IBM kicked off a celebration of its millionth PS/2 with a dealer and press breakfast and what was to be one of the most stylish shows at COMDEX. It began with a carefully staged presentation by National Distribution Division President Ned Lautenbach and Entry Systems Division (ESD) President William Lowe and included a videotaped segment from Chairman John Akers.

Lautenbach reported that each successive quarter has been the best one yet for PC sales, and that selling 1 million PS/2s took 7 months as compared with 28 months for the PC to hit the same mark. He also announced a DOS trade-in program that would allow firms to buy OS/2 at a reduced price.

Lowe's big announcement was that OS/2 Standard Edition 1.0 would ship earlier than planned—in December. The early shipment of 1.0 may have been made to offset the news that version 1.1, the one with the Presentation Manager, would not ship until October 1988. IBM's Extended Edition, Lowe said, would ship in July 1988 without the Presentation Manager and in November 1988 with it.

Lowe also announced PC LAN version 1.3 for July and surprised everyone with the announcement of a product called OS/2 LAN Server version 1.0 to ship next November. Another surprise was Lowe's announcement of AIX for the PS/2 Model 80, available in September 1988; he also reported that the RT PC group was now part of ESD and his responsibility.

Lowe and Lautenbach were followed by executives from a variety of firms, including Bill Gates from Microsoft, Ray Noorda from Novell, Philippe Kahn from Borland, Jim Manzi from Lotus, and Charles Wang from Computer Associates. Each spoke briefly, praising the PS/2 while referring to his own company's products that support (or will support) the family.

The IBM execs were then joined by Jamie Farr and William Christopher, of M*A*S*H fame, who livened up the festivities with a little humor and suggested that IBM might show its gratitude for the success of the PS/2 family by *giving away* the millionth machine instead of *selling* it. After some good-natured resistance from the IBMers, both the millionth PS/2 (a Model 50) and the millionth-and-one (a Model 80) were given away.

I dwell on this because it really is remarkable for IBM to invest so much in telling us how many machines it has sold. According to sanctified IBM tradition, "Thou shalt not reveal sales figures" (at least unit sales). As many times as I have asked in the past, the question has gone politely unanswered. This is a breakthrough, and many of us are asking, "What does it mean?"

Here are at least three reasons why IBM wants to go public with PS/2 sales at this moment. First, it needs to establish that its switch from the PC/XT/AT standard to the PS/2 standard was successful and that customers are buying. In the same vein, it would like to convince all of us that its customers who left the fold for compatibles are now returning, thus increasing IBM's desktop market share.

Second, it needs to capture some attention for itself. Considering that IBM's announcements of last April 2 were its most extensive yet in the desktop arena, both Compaq and Apple have done an extraordinary job during the last year at keeping the spotlight on their products. Compaq might even claim to have benefitted as a result of IBM's announcements; that is sure to rankle the IBM brass.

Third, it needs to capture this attention just as its Model 80s are starting to flow in the channels. IBM surely wants everyone to know that it is in the game to stay, even while the Mac II and the Compaq 386 machines continue to bask in the spotlight.

How significant is IBM's attainment of 1 million PS/2 units sold? Certainly 1 million units, along with a modest upswing in interest in IBM products, indicates that the PS/2 is a successful product introduction. Further, 1 million machines in seven months is an impressive achievement that no competitor is likely to match.

However, in all likelihood, IBM would have sold at least 1 million ma-

chines during those seven months anyway—regardless of the PS/2 family; remember that the first quarter of 1987 was, at that time, IBM's best ever for PC sales. Because IBM had reduced the manufacture of the PC family to the trickle necessary to meet customer commitments, the PS/2 family, in effect, replaced orders that would otherwise have been for ATs or other machines.

IBM's numbers certainly could be daunting to competitors. AST Research, for example, was celebrating having sold 50,000 of its excellent Premium 286 computers during its first year. IBM claims 20 times as many in half the time. It is hard not to be overwhelmed by statistics like that, and it is hard not to respect IBM for its ability to make that kind of business.

LOOKING FOR 20MB

One quest I set for myself during this COMDEX was to seek out a way to increase the hard-disk storage of the PS/2 Model 50, which I have previously identified as seriously lacking in disk capacity (see "What IBM Did Right/Wrong, Part/2," August 1987, p. 46). Any vendor that could solve this problem, I thought, would hit the mother lode.

I made a beeline for the Plus Development booth, hoping to find a prototype of the HardCard 40 for the PS/2. Alas, disappointment was mine. Plus had already rejected the idea of building a Micro Channel version of the disk because it felt that IBM would quickly act to correct its silly Model 50 error by introducing a new model with 30 or 40MB of hard disk instead of the current anemic 20MB.

In the meantime, a spokesman said that Plus was delighted with its role as a leading supplier of hard disks for the PS/2 Models 25 and 30. I would be happy with that; for although IBM has not released sales information by model, most analysts seem to think that at least half of the 1 million PS/2 units the company claims to have delivered are Model 25s or 30s.

My second stop on the quest was Priam, which has a line of external hard disks for the PS/2 Models 50, 60, and 80. The StorageSpace model ED45 includes 45MB of capacity with an average access time of 28 milliseconds; capacities of 62 and 133MB are also available. Unfortunately, the subsystem lists for a very high $1,750; although that may not be too far out of line for 40MB of disk, it is certainly expensive relative to the cost of a Model 50. However, the combined cost of a Model 50 and this drive is still less than the cost of a Model 60, and if you already have a Model 50, this is a way out of capacity problems. In passing, I should note that Priam also has internal drives for Models 60 and 80; the 330 drive is priced at $4,540, or almost $2,000 less than IBM's 314MB drive.

I got excited again when I hit the Rodime booth. There I saw a clever product called DoublePlay, which includes a 45MB, 28-ms-access hard disk that replaces the original Model 50 disk. For the Model 50, DoublePlay yields more than twice the capacity and nearly three times the performance compared to the IBM drive.

After the installation, however, the Model 50 owner is left with a 20MB hard disk. DoublePlay offers a creative solution to this problem by including a controller board that allows the IBM drive to be installed in a Model 25. Of course, that means you have to have a Model 25, and if a business is buying Model 50s or better, would it really have any Model 25s?

Rodime's list price for DoublePlay is $1,795. Again, this is high; maybe the company should consider eliminating the Model 25 electronics and reduce the price accordingly.

Sadly, these were the only two solutions I found to the Model 50 storage problem (although I did not get into every nook and cranny of COMDEX).

EMS 4.0 UPDATE

Intel PCEO was in the news again, this time with the introduction of a 2MB expanded/extended memory board for PS/2 Models 50 and 60. Called Above Board 2, this product has two noteworthy characteristics.

Number one, this is the first Intel offering with additional hardware support for EMS, but the support goes beyond what we might have expected. The board is compatible with IBM's 80286 Memory Expansion Option for the Models 50 and 60, which has 1,024 page registers, each of which can map a 16KB page anywhere into the processor's 16MB address space. That is certainly a welcome announcement. Intel had no comment about plans for its other boards, but it is safe to assume that updates are forthcoming, either to match the PS/2-style boards or at least to bring the hardware to a level similar to that of AST's memory boards.

The second interesting feature of the Above Board 2 is that its maximum memory is 2MB, the same as the maxi-

mum offered by IBM. This is a very curious development because for PC-class machines, third-party vendors always offered at least twice as much memory as IBM. But beyond Tecmar's announced 8MB board for the PS/2 and the IDEAssociates 12MB IDEAmax/MC for Models 50 and 60, most vendors have stuck with the 2MB maximum.

Intel claimed that 2MB was the maximum supported by the PS/2 and stated that compatibility was more important than capacity. In general, I agree with the latter, but it is not strictly true that 2MB is a PS/2-imposed limitation. Technical Editor Ted Mirecki reports that 2MB is the maximum that the PS/2 power-on self test (POST) will check, but a DOS driver can be loaded to check additional memory if desired. Once running, DOS has no problems with the size of memory boards. A more accurate interpretation might be that the behavior of a greater-than-2MB board with OS/2 is less understood, so 2MB maximums represent caution for the moment. Note also that 1,024-page registers, at 16KB per page, represent 2MB, so greater memory sizes require proportionally more registers.

Another piece of EMS news is actually non-news: Compaq has not yet released a version of CEMM (the Compaq expanded memory manager) that is compatible with EMS 4.0. Those with 386 systems are advised to look at 386-to-the-Max from Qualitas, which includes a certified EMS 4.0-compatible driver. (386-to-the-Max was reviewed in Product Watch, December, p. 197.)

Mirecki also got a look at Quarterdeck's QEMM driver, which is not only upgraded to EMS 4.0 but also runs on the IBM memory boards for PS/2 machines. As far as we know, this is the first driver to do so.

AND FINALLY

I was impressed at how fast the industry has responded to IBM's Video Graphics Array (VGA). Clones were everywhere (I like Video Seven's and Compaq's in particular); interestingly, Compaq managed to have a product in the same time frame as other vendors specifically in the video adapter market. I was also gratified to see a variety of 3.5-inch diskette solutions for PC-class machines as well as progress being made toward 1.2MB diskette solutions for PS/2 machines.

This was a busy, but exciting COMDEX. I am looking forward to the spring show to see if all the promises made come true.

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OF SERIOUS 4GL/

ZIM, the Fourth-Generation Language Database Management System that has set new standards in Power, Performance, Productivity and Portability welcomes you to the world of serious application development.

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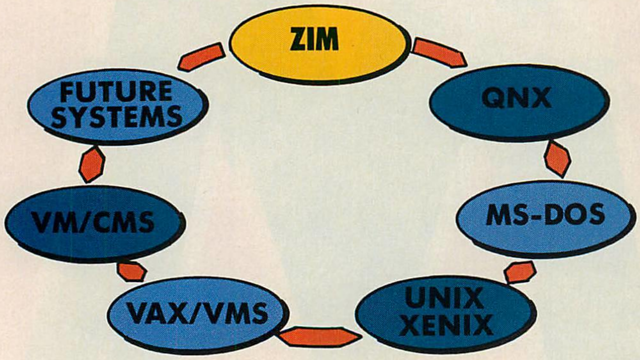
PORTABILITY: Complete micro-to-mainframe portability means applications can be developed on PC's and immediately implemented in the client environment with no code changes. Our growing list of compatible operating environments encompasses the world of serious technology: single user MS-DOS, MS-DOS networks, Novell networks, QNX, UNIX, XENIX, VAX/VMS and VM/CMS.



100 percent portability

DEVELOPMENT ASSISTANT: ZIM/DA (ZIM's development assistant companion product) is a key element in **ZIM's** productivity and CASE offerings. **ZIM/DA** is comprised of an application generator, menu generator, active and comprehensive data dictionary, report painter, code editors and context-sensitive help. **ZIM/DA** permits remarkably fast transition from prototype to finished application.

THE ZIM LANGUAGE: Time is money. It shouldn't be spent writing endless lines of code or worse, tying up expensive mainframe systems. The **ZIM** language, based on the entity-relationship (E-R) model, provides the power that serious application developers demand. Compare a typical SQL command and the **ZIM** equivalent:

SQL:

```
SELECT *
FROM WORKONTAB, PROJECTS, EMPLOYEES-
WHERE WORKONTAB.ENUM=EMPLOYEES.ENUM-
AND WORKONTAB.PNUM=PROJECTS.PNUM-
AND PROJNAME='ALPHA'
```

ZIM:

```
LIST ALL EMPLOYEES WORKON PROJECTS WHERE
PROJNAME='ALPHA'
```

DEBUGGING: ZIM's active data dictionary plays an integral role in reducing debugging time. Use the PARSE command to verify coding accuracy and context. Singlestep execution aids in debugging.

POWER: ZIM is rich in powerful features and functions such as:

- AI-based access strategy analyser.
- Unsurpassed computational abilities, including CASE expression which handles with ease the 'step' functions found in real-world business applications.

THE WORLD DBMS PROGRAMMING

- Natural multi-user features including user-defined transactions, roll-back, audit trails and roll-forward.
- Complete code-data independence.
- Exceptional text-handling capabilities.
- Unlimited forms manipulation and report-writing capabilities.
- Multi-lingual applications (French, German etc.)

SECURITY: ZIM's multi-level security features include log-in, passwords, permission-based access to entity sets, relationships and fields and encryption/decryption of entity sets and relationships.

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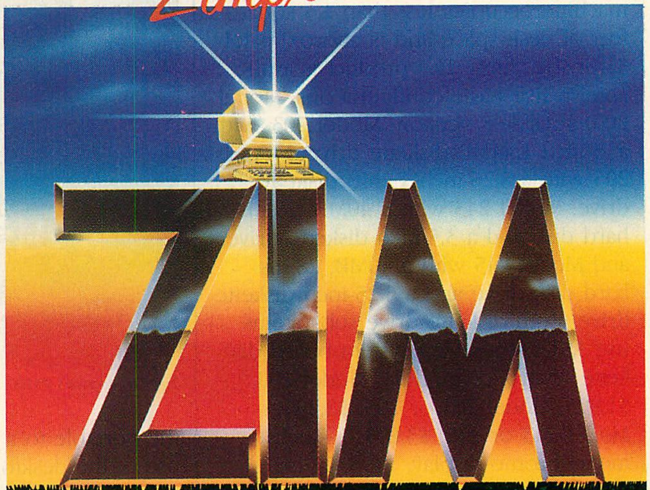
ZIM is supported by an ever-growing family of companion products like **Niva's Guide to ZIM** (the authoritative guide from introductory to expert levels), the **ZIM Compiler** to ensure the highest level of performance of your **ZIM** application, a **Program Language Interface** permits "C" access to **ZIM** databases, **ZIM-ISQL** allows queries based on SQL syntax, **Runtime** and **Query Runtime** systems and **ZIMPLE,** an add-on module that permits easy use, allows end-users to create their own simple applications, ad hoc queries or paint their own reports (used with **ZIM** or **Query Runtime**).

And you'll be supported too! Zanthe's Priority Support program includes first-rate telephone technical support, free updates, new versions and periodic technical bulletins. **Code Review** and **Training** services are available for all levels of **ZIM** users.

Around the world, from Australia to Europe, **ZIM Service Centers** and **Distributors** stand ready to supply and assist any **ZIM** user.

Already an integral part of data management in national governments, international banks, financial corporations and thousands of other applications **ZIM** welcomes you to the world of serious application development.

Zimpressive!



Zanthe Information, Inc.
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CIRCLE NO. 237 ON READER SERVICE CARD

TECH RELEASES

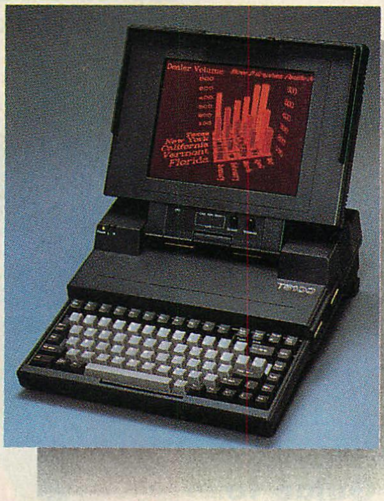
The latest in hardware, software, and technology for systems developers and integrators.

AST Premium Workstation from AST Research, Inc.

SYSTEMS

AST Research, Inc. has announced the **AST Premium Workstation**, an 80286-based microcomputer with two selectable speeds of 10 MHz or 6 MHz with one wait state. Key system features include 1MB of RAM, two full-length 8/16-bit expansion slots, two serial ports, bidirectional parallel port, support for an 80287, and a removable video adapter module that provides extended EGA, CGA, MDA, and Hercules compatibility. The Premium Workstation is compatible with the IBM PC/AT standard and with Microsoft Operating System/2 (MS-OS/2). The machine occupies less than 1.5 square feet of desk space and is approximately 3.4 inches high. The product is available in five basic configurations: Model 200, a diskless version; Model 203, with a .5-inch 1.44MB diskette drive; Model 205 with a 5.25-inch 1.2MB diskette drive; Model 243 with a 40MB, 28-ms hard disk and a 3.5-inch diskette drive; and Model 245 with a 40MB, 28-ms hard disk drive and a 5.25-inch diskette drive. Both diskette drive subsystems use AST's slot-saving system board diskette controller module. Model 200, $1,995; Model 203 or 205, $2,295; Model 243 or 245, $3,295; 14-inch monochrome display, $195; 14-inch enhanced color display, $695.
AST Research Inc., 2121 Alton Avenue, Irvine, CA 92714; 714/863-1333
CIRCLE 301 ON READER SERVICE CARD

An 80386-based microcomputer has been added to **Toshiba America, Inc.**'s family of portable systems. The **T5100**, a small, 15-pound unit, 3.5 inches high by 14.2 inches deep, comes standard with a 16-MHz 386, a socket for an 80387, 2MB of RAM, a 40MB hard disk, and a 3.5-inch 1.44MB diskette drive. The T5100 features a built-in EGA display system with a high-resolution gas plasma screen and an EGA monitor port. The screen supports four grey scales and features 640-by-400 bit-mapped graphics and 80-column-by-25-line text with adjustable contrast and brightness controls. A designated slot houses an optional interface card ($199) for a five-card, IBM-compatible expansion chassis ($999) or Hayes-compatible modem card ($399). Other options available include an external 5.25-inch 360KB diskette drive ($499), and a Floppy Link ($199) that cables



Toshiba America's T5100, an 80386-based portable

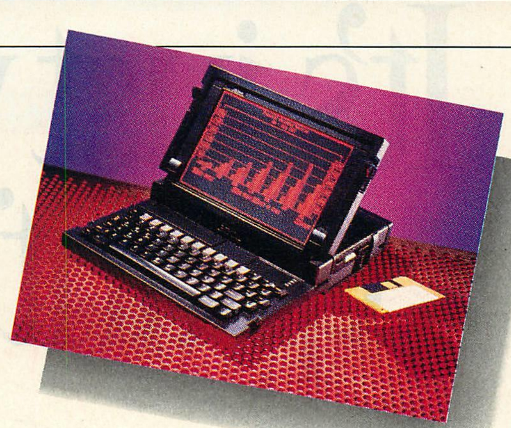
the portable to a desktop PC, allowing use of the desktop's 5.25-inch diskette drive. T5100, $6,499.
Toshiba America, Inc., Information Systems Division, 9740 Irvine Blvd., Irvine, CA 92718; 714/380-3000
CIRCLE 302 ON READER SERVICE CARD

Battery-powered, light-weight laptop computers based on the 80C286 and 80C386 have been announced by **GRiD Systems Corporation.** The new **GRiDCase 1500 Series** laptops offer 3270, VGA, and GRiDLink LAN support. Standard features on the 1500 series AT-compatible laptops include a 10-inch-diagonal, supertwist backlit LCD screen (80-column by 25-line); 1MB RAM (expandable to 8MB); two 1.4MB, 3.5-inch internal diskette drives; and up to 512KB of user-installable ROM packs. The unit comes in a rugged magnesium case and weighs 12 pounds. Options available on the 1500 Series models include 640-by-200 or 640-by-400 bit-mapped gas plasma displays, 10MB or 20MB internal disk drives with a diskette drive, a 40MB internal hard-disk drive, an 80287, 2400/1200/300 bps internal modem, and an internal NiCad rechargeable/removable battery pack. In addition, removable expansion cartridges that offer 3270, VGA, and GRiD-Link LAN support are also optional. Series Model 1520 uses an 80C286 at 10 MHz while Model 1530 has an 80C386 running at 12.5 MHz. Model 1520, $3,495; Model 1530, $4,695.
GRiD Systems Corporation, 47211 Lakeview Blvd., Fremont, CA 94538; 800/222-4743; 415/656-4700
CIRCLE 303 ON READER SERVICE CARD

CONNECTIONS

Products to enhance Token-Ring connectivity have been introduced by **IBM Corporation**. The **IBM Token-Ring Network Trace and Performance PC Adapter II** and **IBM Token-Ring Network Trace and Performance Adapter/A** are cards for PCs and the IBM Personal System/2 machines that work in conjunction with the **IBM Token-Ring Trace and Performance Program**, a menu-driven program. Together, these new products will provide visibility to traffic handled by the ring and they will also perform data throughput measurements on IBM Token-Ring Networks. In addition, when they are not in trace or performance mode, these adapters operate as IBM Token-Ring Network adapters. The trace function is a valuable tool for use in analyzing application programs using

IRMAcom2, a controller emulator from DCA



GRiDCase 1500 Series laptop from GRiD Systems

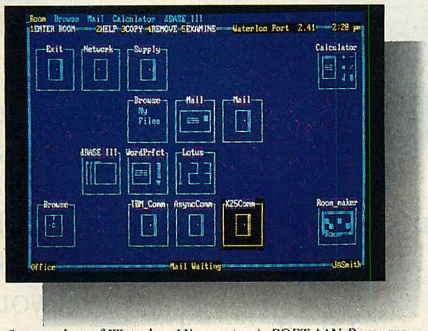
different protocols on the ring. The performance function provides insight into the use of the ring by all or a subset of stations. IBM Token-Ring Network Trace and Performance PC Adapter II, $1,320; Token-Ring Network Trace and Performance Adapter/A, $1,220; Token-Ring Network Trace and Performance Program, $295.
IBM Corporation, Information Systems Group, 900 King Street, Rye Brook, NY 10573; 800/426-2468; for nearest dealer, 800/447-4700

CIRCLE 304 ON READER SERVICE CARD

An enhanced version of IRMAcom, a remote communications product that provided communications capabilities between PCs and IBM mainframe computers that are not directly attached to each other, has been announced by **Digital Communications Associates, Inc.** (DCA). The new version, known as **IRMAcom2**, is a controller emulator that offers the user the same functionality that IRMA provides to users that are directly attached to the mainframe. IRMAcom2 supports expanded memory, DCA's High-level Language Application Program Interface (HLLAPI) version 1.0, and third-party software developed for use with IBM's HLLAPI. It also offers the Mod 5 screen display, which provides the user with a full view of 132 columns by 27 lines; provides the user with a set of optional C subroutines for interfacing with user-written programs; and supports DCA's ForteNet high-speed file transfer software. As with IRMAcom, IRMAcom2 provides the user with up to five concurrent host sessions, hot-key capabilities, 3287 printer emulation, and compatibility with the mainframe portion of DCA's IRMAlink FT/TSO, FT/CMS, and IBM's 3270 PC file transfer software. Two versions of IRMAcom2 are available: IRMAcom2 SNA for communications in an SNA environment, and IRMAcom2 BSC for communications is a BSC environment. SNA or BSC versions, $895 each; upgrade to IRMAcom2 (for existing ForteLink SNA and IRMAcom users), $395.
Digital Communications Associates, Inc., 1000 Alderman Drive, Alpharetta, GA 30201-4199; 800/241-4762; 404/442-4000

CIRCLE 307 ON READER SERVICE CARD

Six new software products introduced by **Waterloo Microsystems** incorporate its Internet Gateway Control Program (IGCP) which provides security and network management tools needed to internetwork Waterloo PORT LANs. The **Waterloo PORT PC LAN Program**



Screen shot of Waterloo Microsystem's PORT LAN Program

connects stand-alone IBM PC, PC/XT, PC/AT, and PS/2 machines to form a multiuser network. When used with other PORT software, the program connects PC networks to mainframes, minicomputers, and remote PCs and it also provides for both local and remote internetworking between LANs with security and network management features. Features include resource sharing, choice of icon or DOS interface, DOS 3.X file and record locking, NETBIOS interface support, data integrity, multilevel security, electronic mail facility, and a VRAM option. $1,895.

The **PORT Backbone Internet Gateway** enables an ARCNET-based LAN or an IBM Token-Ring Network to serve as a backbone LAN for connecting one or more Waterloo PORT LANs to form an internetwork. Features include local LAN-to-LAN communication, the ability to connect up to two LANs, gateway management, identical user interface, support for different network hardware, and the ability to pass file and record locks. $2995.

The **PORT X.25 Server** (point-to-point) runs in an IBM PS/2, PC, XT, AT, or compatible and allows PCs in a Waterloo PORT LAN to communicate with another LAN via a direct synchronous connection. Some features include support of transmission speeds up to 64 Kbps, error-free communication, detailed audit trail of all sessions, ability to pass visitor-IDs, and support of different network hardware. $1,995.

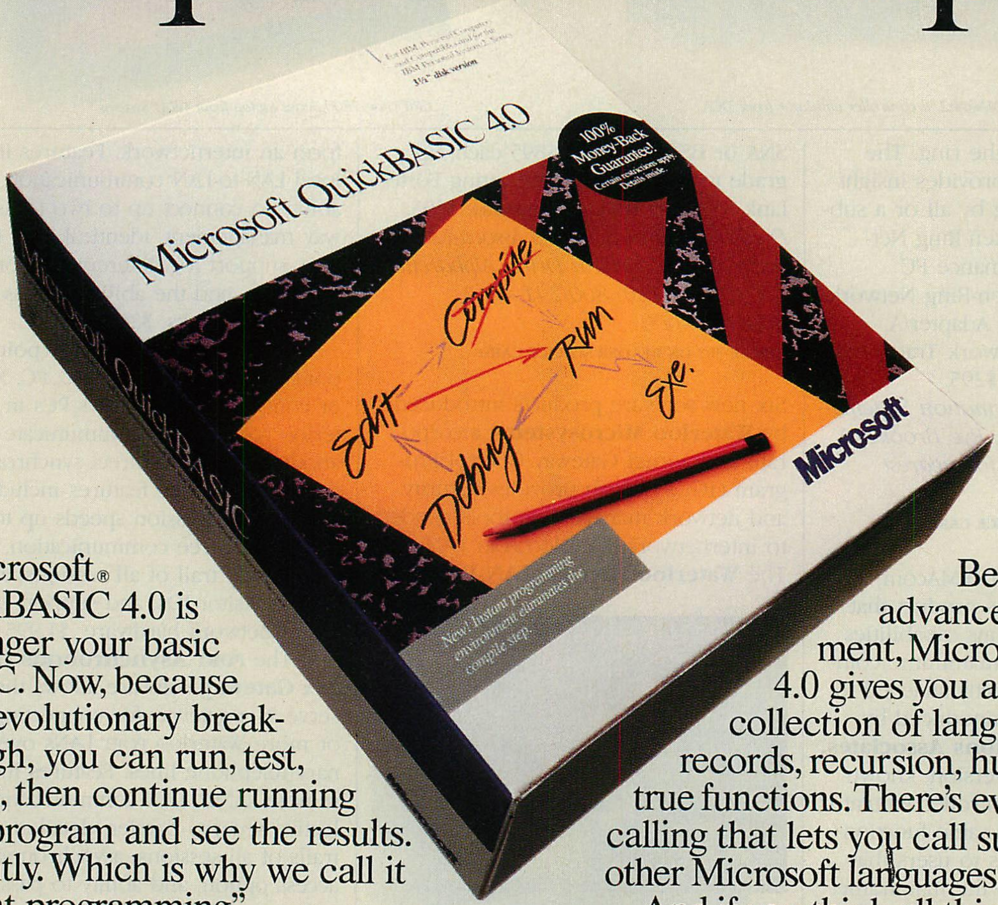
The **PORT Asynchronous Internet Gateway** software allows the PC to serve as a gateway for connecting two or more Waterloo PORT LANs over ordinary telephone lines. Features include remote LAN-to-LAN communication, selective security barrier, detailed audit trails of all sessions, asynchronous X.25 access option, and ability to pass file and record locks. $1,495.

The **PORT Remote Workstation** software allows a stand-alone or portable PC remote from a PORT LAN to access services located in a LAN or another PORT Remote Workstation, and allows a LAN to access Remote Workstation services. Features include TTY and VT100 terminal emulation support, remote system management, detailed audit trails of all sessions, identical user interface, ability to pass visitor-IDs, and an asynchronous X.25 option. $395.
Waterloo Microsystems, 3597 Parkway Lane, Suite 200, Norcross, GA 30092; 404/441-9252

CIRCLE 310 ON READER SERVICE CARD

A communications package offering Advanced Program-to-Program Communication (APPC), or Logical Unit type 6.2 (LU6.2) protocol, has been announced by **Network Software Asso-**

It's just your basic quantum leap.



Microsoft® QuickBASIC 4.0 is no longer your basic BASIC. Now, because of a revolutionary breakthrough, you can run, test, debug, then continue running your program and see the results. Instantly. Which is why we call it "instant programming."

Other compilers make you wait while they compile your program at an unimpressive rate of 12,000 lines per minute. But Microsoft QuickBASIC 4.0 translates your program into executable code at a breathtaking 150,000 lines per minute. You get all the speed you can possibly use right when you need it. While you're developing your program.

And for the first time in BASIC, you'll find the most sophisticated debugging tools around. Like the freedom to change a running program on the fly. Without restarting. And you also get instant syntax checking, watch expressions, even runtime type checking.

Besides all these advances in the environment, Microsoft QuickBASIC 4.0 gives you a sophisticated collection of language extensions: records, recursion, huge arrays and true functions. There's even interlanguage calling that lets you call subroutines from other Microsoft languages.

And if you think all this means you might have to give up phenomenal execution speed, think again. Microsoft QuickBASIC 4.0 gives high performance executable code that's the fastest anywhere.

About the only thing that isn't more advanced in Microsoft QuickBASIC 4.0 is the price.

It's still just $99. And it's still backed with a 30-day money back guarantee. Microsoft QuickBASIC 4.0.

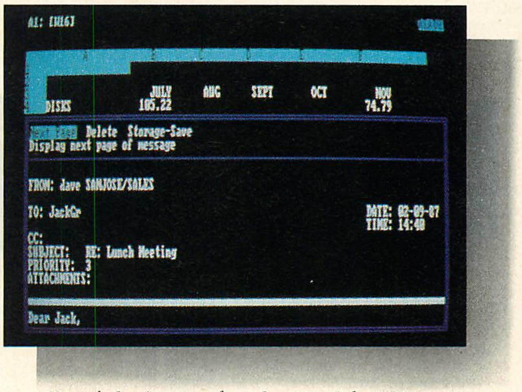
To make a quantum leap in your programming, you need a quantum leap in your language.

Microsoft® QuickBASIC 4.0

For the name of your nearest Microsoft dealer, call (800) 541-1261, Dept. B15.

CIRCLE NO. 120 ON READER SERVICE CARD

Compaq's Video Graphics Color Monitor



Network Courier screen from Consumer Software, Inc

ciates, Inc. (NSA). The new software, known as **Async/APPC,** allows an IBM PS/2, PC, or compatible to use its serial port to communicate with another PS/2 or PC. Async/APPC uses the PC's standard serial port plus an asynchronous modem, or two PCs can be hard-wired together via their serial ports without the use of modems. Async/APPC is compatible with all other NSA LU6.2 products. $285.
Network Software Associates, Inc., 22982 Mill Creek, Laguna Hills, CA 92653; 714/768-4013
CIRCLE 311 ON READER SERVICE CARD

Support for Microsoft Windows/386 for the **Network Courier**, an electronic mail system, has been announced by **Consumers Software, Inc.** The Network Courier features support for as many as 150 users per post office, automatic address list exchange for sharing local user address lists with other networks within a company, support for aliases and group names, notification to sender when the message has been read by receiver, access by remote PC users, and adherence to CCITT X.400 protocol. The Windows/386 version of Network Courier allows users of character and graphics-based applications to coexist and share messages and files on the same LAN. The user is notified of mail as it arrives by the appearance of a flashing mail icon. Even messages originating on external systems, such as IBM Profs or other remote Network Courier LAN, give instant notification of arrival. Single-copy, 6-user version, $295; network server, $695; multiple servers, $995 each.
Consumers Software, Inc., 314 E. Holly Street, Suite 106; Bellingham, WA 98225; 800/663-8935
CIRCLE 309 ON READER SERVICE CARD

Connect Computer Company, Inc., is offering three versions of the **WonUnder**, a single-card expansion unit for the Toshiba T3100 portable computer bundled with connectivity cards for networking or mainframe emulation. The basic WonUnder package consists of the metal card carrier, WonUnder interface card, and an illustrated installation and reference guide. The WonUnder with Arcnet bundle includes all items in the basic WonUnder package, plus an Arcnet expansion card. The WonUnder with Ethernet bundle includes the WonUnder package and an Ethernet expansion card. The WonUnder with mainframe emulation card bundle includes the basic

Connect Computer's WonUnder for Toshiba's T3100

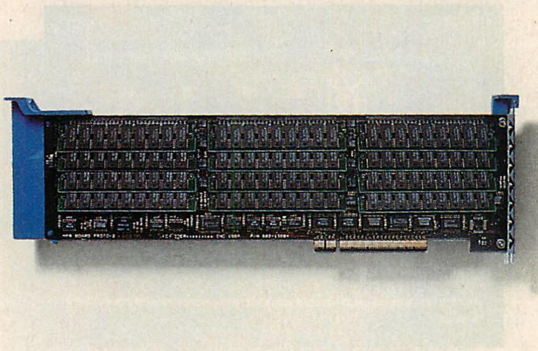
WonUnder package plus a CXI 3270 emulation board. WonUnder, $349; with Arcnet bundle, $629; with Ethernet bundle, $779; with mainframe emulation card bundle, $1,195.
Connect Computer Company, Inc., 9855 W. 78th Street, Suite 220, Eden Prairie, MN 55344; 612/944-0181
CIRCLE 312 ON READER SERVICE CARD

PERIPHERALS

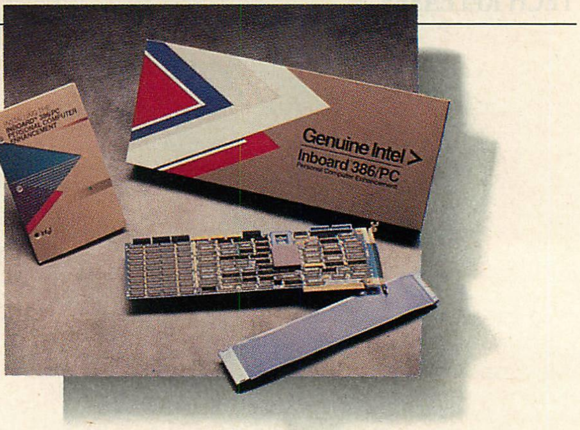
New monitors and controller boards that incorporate features compatible with IBM's PS/2 family of computers have been announced by **Compaq Computer Corporation**. The **Compaq Video Graphics Controller Board** boasts a 50 percent performance increase (depending upon application) over the IBM PS/2 Video Graphics Array (VGA); the increase results from 16-bit operation, improved bus arbitration, and display memory buffering. The Compaq Video Graphics Controller Board is fully compatible with both the 8-bit and 16-bit industry-standard data bus, but maximum performance is achieved when it is used in a 16-bit expansion slot. A connector feature on the controller board allows a future controller board supporting greater than 640-by-480 resolution to be connected while still retaining CGA, EGA, and VGA compatibility.

When used with the Compaq Video Graphics Controller Board, the **Compaq Video Graphics Color Monitor** and **Compaq Video Graphics Monochrome Monitor** can display a graphics resolution of 640 by 480, and a text resolution of 720 by 400. The Color Monitor offers support for up to 256 simultaneous colors on a 14-inch-diagonal analog color monitor, and the Monochrome Monitor provides support for up to 64 shades of gray on a 12-inch-diagonal white phosphorus analog monitor. Both monitors include noninterlaced scanning to reduce monitor flicker, a diagnostic self-test, antiglare screens, a tilt/swivel base, an internal power supply, brightness and contrast controls, and 6-foot power and signal cables. $599.

Also announced by Compaq is the internal **Compaq Expanded Memory Board** option that is designed specifically for the Compaq Portable III to provide Portable III owners access to expanded memory above 640KB when using software following the Lotus/Intel/Microsoft expanded memory specification (LIM EMS) version 3.20. Extended memory is supported. The 12-MHz Compaq Expanded Memory Board occupies an internal expansion slot within the Portable III, and holds



IDEAmax/MC memory and multifunction board from IDEAssociates



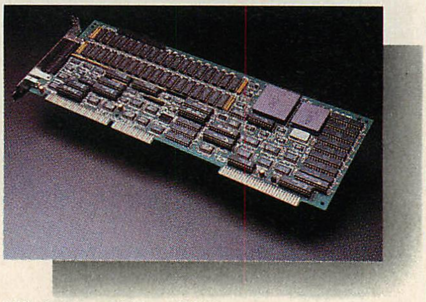
Intel Inboard 386/PC add-in board

optional memory upgrade modules that can take the RAM in the Portable III to a maximum of 6.6MB. $299.
Compaq Computer Corporation, 20555 FM 149, Houston, TX 77070; 713/370-0670
CIRCLE 313 ON READER SERVICE CARD

An 80386-based add-in board that boosts performance in IBM PC, XT, and compatibles as much as 10 fold has been announced by **Intel Corporation**. The **Inboard 386/PC** has no switches or jumpers to set. A special adapter plug connected to the ribbon cable replaces the 8088. A socket for the 80387 is provided. The standard memory configuration memory is 1MB; an optional 2MB **Piggyback Memory board** provides 3MB of memory in a single slot. Inboard 386/PC, $995; 1 MB Piggyback Memory board, $645; 2 MB Piggyback Memory board, $1,145.
Intel Corporation, Mail Stop C03-07, 5200 N.E. Elam Young Pkwy., Hillsboro, OR 97124-6497; 800/538-3373
CIRCLE 314 ON READER SERVICE CARD

Two memory and multifunction boards for the IBM PS/2 machines Models 50, 60, and 80 have been introduced by **IDEAssociates, Inc.** The **IDEA-max/MC** offers 12MB of memory; **IDEA Supermax/MC** provides up to 8MB of memory and a serial and a parallel port. Both boards allow users to allocate 8MB as expanded memory, which is compatible with the Lotus/Intel/Microsoft expanded memory specification (LIM EMS). For high memory capacity on one card, both boards use 1MB single in-line memory modules (SIMMs), vertically mounted on the board's surface. Using 256KB SIMMs, the IDEAmax/MC has a capacity of 3MB; the IDEA Supermax/MC has a capacity of 2MB. Both boards may be configured with a combination of 1MB and 256KB chips; both use surface-mount technology (SMT). Software enables users to create a RAM disk, includes print-spooling features, and has complete memory diagnostics. IDEAmax/MC with 512KB, $495; IDEA Supermax/MC with 512KB, $645.
IDEAssociates, Inc., 29 Dunham Road, Billerica, MA 01821; 617/663-6878
CIRCLE 318 ON READER SERVICE CARD

A high-performance enhancement board that enables AST Premium/286 users to upgrade to full 80386 capabilities is available from **AST Research, Inc. The Premium FASTboard/386** offers 16-MHz, 80386 processing power and up to 9MB of dynamic memory with an optional piggyback card. Switching from 80286 to 80386 processing is accomplished using an exter-



AST's Premium FASTboard/386

nal toggle switch on the board bracket. A ROM redirector utility allows AST Premium ROM BIOS calls to be redirected to local 32-bit memory. Support for EMS 4.0 applications in local memory with expanded memory software driver DOS utilities allows keyboard-selectable speed and cache change for 80386. $1,995.
AST Research, Inc., 2121 Alton Avenue, Irvine, CA 92714-4992; 714/863-1333
CIRCLE 315 ON READER SERVICE CARD

Everex Systems, Inc. has introduced the **RAM II 2000**, a 2MB memory expansion board for the IBM PS/2 Models 50 and 60. The board is fully compatible with IBM's own Memory Expansion Option and fits into one of the Micro Channel slots. The RAM II 2000 uses 1 megabit dynamic RAM (DRAM) chips to provide the 2MB on a single board. Installation requires no jumpers or DIP switches and no ADF file because it is configured automatically when the Model 50 or 60 is powered-up. The RAM II 2000 can coexist with other memory boards from Everex or IBM. It supports expanded memory and extended memory as well as Dynamic Memory Relocation. Compatibility with the Lotus/Intel/Microsoft expanded memory specification (LIM EMS) is provided by the ELM software that is included as a standard feature. $399.
Everex Systems, Inc., 48431 Milmont Drive, Fremont, CA 94538; 800/821-0806; 800/821-0807
CIRCLE 316 ON READER SERVICE CARD

An **IBM Enhanced Memory Expansion Adapter** for the PC/AT or the XT-286 that offers up to 12MB of memory on a single adapter or 15MB total with two adapters, and that supports expanded memory and OS/2 has been announced by **IBM Corporation**. The adapter, which includes AboveDisc EMS emulation software, gives the user both extended and expanded memory emulation. The board features split-memory addressing; parallel and serial printer ports and adapters can be used to provide a maximum of two parallel and two serial ports.

IBM also introduced a **2MB Memory Module Kit**, which includes two 1MB memory modules, to double the capacity of the Enhanced Memory Expansion Adapter to 12MB. The total system memory for the AT and XT-286 now can be expanded to the 16MB limit by installing two adapters. Publications available: *Hardware Maintenance and Service Manual*, order number G570-2239 part number 74X8316; *Technical Reference Manual*, order number

The Leaders Made PVCS The Leading Source Code Control System.

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When it comes to maintaining their most valuable asset, the leading software publishers rely on the POLYTRON Version Control System (PVCS). From accounting firms to airlines, the leading service companies depend on PVCS to maintain the integrity of their programs. Leading manufacturing companies use PVCS to maintain their state-of-the-art software. Leading high technology companies turn to PVCS to handle configuration management for software projects that represent an investment of hundreds of thousands of dollars. The largest aerospace companies and defense contractors use PVCS to maintain integrity of projects during development and after delivery of software. Independent programmers use PVCS to improve their productivity and software quality for themselves and their clients.

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When large and complex software programs are being developed on personal computers or VAX minicomputers, effective management of the revisions and versions becomes critical. PVCS simplifies this process and lets you effectively control the proliferation of code changes. We used UNIX SCCS and RCS as models. However, our own experience, and the input of hundreds of programmers and managers has enabled us to significantly improve upon these models.

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Now, companies that develop software on VAX systems running VMS can also use PVCS. And since the VMS and MS-DOS versions of PVCS use the same "logfile" format, you can easily develop software on PCs and maintain the code on the VAX or vice versa. The menu-driven, screen-oriented interface (and optional command-driven interface) makes it easy for programmers and librarians or administrators to use PVCS on a PC or VAX or both systems.

PVCS Maintains System Integrity

PVCS prevents corruption of code that could ordinarily result from security breaks, user carelessness or malfunctions. The levels of security can be tailored to meet the needs of your project.

PVCS & PolyMake Work Together

PolyMake, the leading MS-DOS make utility, is now available for the VMS operating system. This allows you to write makefiles that will function in both PC and VAX environments. Additionally, PolyMake reads time & date stamps of PVCS archives for fast, accurate program rebuilding.

PVCS and PolyMake Maintain Source Code Written In Any Language.

The Preferred Version Control System

The customers listed below are just a few of the innovative leaders that have made PVCS the leading version control program for personal computers.

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Arthur Anderson
AT&T
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Bank of America
Bell Labs
Bendix
Boeing
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Citibank
3Com
Colonial Penn
Commerce Clearing House
Control Data Corp.
Corvus
CXI
Digital Equipment Corp.
Deloitte Haskins + Sells
Diebold
Dow
Dunn & Bradstreet
EDS
Educational Testing Service
E-Systems
Equitable Life
Federal Express
First Boston
Ford
Fox Software
Fujitsu
GTE
Hardees
Hewlett-Packard
Honeywell
Hughes Aircraft
IBM
Industrial Networking
Intel
ISC Aerospace
IVAC
Javelin
Lattice
Lawrence Livermore
Lotus
McData Corp.
McDonnell Douglas
Mead Data Central
MIT Lincoln Labs
Nastec
Novell
NCR Technologies
Pitney Bowes
Plexus Computers
Price Waterhouse
ROLM
Rockwell International
Safeco
Sears
Security Pacific
Sperry
Software Publishing
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Standard Oil
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Corporate PVCS — Offers additional features to maintain source code of very large and complex projects that may involve multiple programmers. Includes multi-level branching to effectively maintain code when programs evolve on multiple paths (e.g. new versions for different host systems, or a new program based on an existing program).

Network PVCS — Extends Corporate PVCS for use on Networks. File locking and security levels can be tailored for each project.

PVCS for VAX systems — Requires VMS. Uses the same interface and archive format as MS-DOS version. Supports branching and offers file locking and other security features for multiple-programmer projects.

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Network PVCS	$995**	$4,950	$9,500	$10,500+
PolyMake	$149			
Network PolyMake	$447**	$1,250	$2,375	$2,500+

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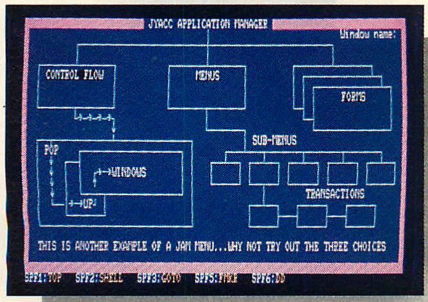
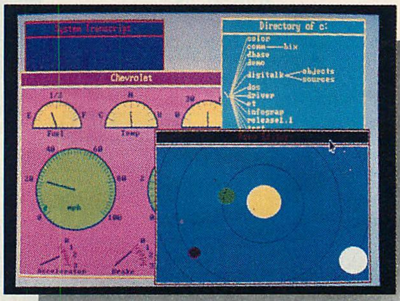


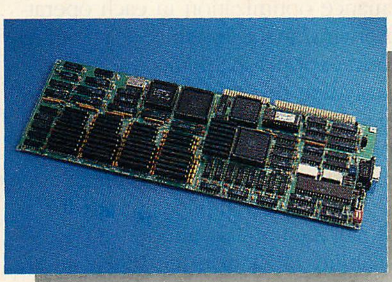
Screen from JYACC Application Manager



Smalltalk/V version 2.0 screen from Digitalk, Inc.

G570-2240 part number 74X7717. Enhanced Memory Expansion Adapter, $495; 2MB Memory Module Kit, $845.
IBM Corporation, Information Systems Group, 900 King Street, Rye Brook, New York 10573; 800/426-2468; for nearest dealer, 800/447-4700
CIRCLE 317 ON READER SERVICE CARD

A multisynchronous graphics card, the **MultiSync Video Adapter 1024** (MVA 1024), is available from **NEC Home Electronics, Inc.** It supports the NEC MultiSync family by driving the original MultiSync monitor at 640-by-480 and lower resolutions, the MultiSync Plus at 960-by-720 and lower, and the MultiSync XT at 1024-by-768 and lower. Using Direct Graphics Interface Standard (DGIS) and Professional Graphics Language (PGL), the MVA 1024 can support a vast array of software in addition to supporting EGA-, PGC-, and CGA-compatible software. Other features are analog signal, 9-pin connector and 9-pin to 4 BNC cable, text modes from 40-columns-by-25-rows to 132-columns-by-43-rows, and compatibility with 16-bit systems. $1,995.



MultiSync Video Adapter 1024 from NEC

NEC Home Electronics (U.S.A.), Inc., 1255 Michael Drive, Wood Dale, IL 60191-1094; 312/860-9500
CIRCLE 321 ON READER SERVICE CARD

Now shipping from **Quadram Corporation** is the **Mighty Meg**, a 14.5MB extended memory board that uses single in-line memory module (SIMM) technology for memory upgrades. The Mighty Meg is compatible with XT-286, AT, and 80386-based machines, and it is available in memory configurations ranging from 512KB to 14.5MB. The memory board can be expanded incrementally to 4MB using nine 256KB SIMMs devices, or to 14.5MB using nine 1MB SIMMs devices. 512KB version, $545; 14.5MB version, $4,995.
Quadram Corporation, One Quad Way, Norcross, GA 30093-2919; 404/923-6666
CIRCLE 320 ON READER SERVICE CARD

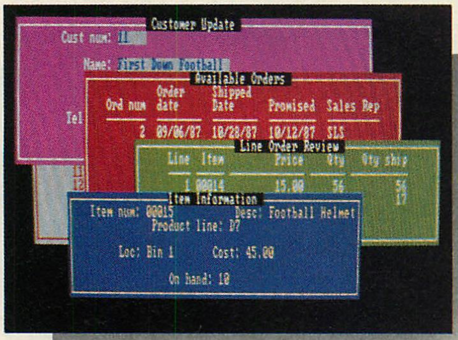
SOFTWARE DEVELOPMENT

JYACC, Inc. has introduced the **JYACC Application Manager** (JAM), an interactive management system that allows application developers to customize and standardize user interfaces from a variety of software applications. Available on a broad range of CPUs and operating environments, JAM allows application developers to design and automatically link together the screens that comprise the user interface for any application without coding or programming. JAM includes a complete range of screen-painting facilities, such as support for windows, menus, and color. In addition, JAM offers context-sensitive help, full testing capabilities, and is self-documenting. JAM includes a screen and window manager, **JYACC FORMAKER**, which allows users to design, develop, test, and document screens. Single-user PC environment, $750; JYACC FORMAKER only, $495.
JYACC, Inc., 116 John Street, New York, NY 10038; 800/458-3313; 212/267-7722
CIRCLE 325 ON READER SERVICE CARD

An object-oriented programing tool, **Smalltalk/V version 2.0**, has been released by **Digitalk, Inc.** This release supports high-resolution graphic modes (640-by-480 pixel VGA and MCGA modes). A fast, bit-mapped window and mouse-driven interface in Smalltalk/V allows users to open many windows of any size and function. The system includes a tutorial, complete source code, bit and form editors for the creation of fonts and icons, an object-oriented Prolog interpreter for integrating logic programming into Smalltalk programs, and an object-swapping virtual memory scheme that gets around the DOS 640KB memory barrier. Drivers for the Toshiba T3100 and IBM 3270 PC are included. $99.95; upgrade for previous releases, $25.00.
Digitalk, Inc., 9841 Airport Blvd., Los Angeles, CA 90045; 213/645-1082
CIRCLE 324 ON READER SERVICE CARD

An 80386 compiler, **NDP Fortran-386**, has been introduced by **MicroWay**. Combined with MicroWay's 80386 (mW1167), NDP Fortran-386 runs 16 times faster than a PC/AT with an 80287, and it also runs with the 80287 and 80387. The speed of execution is due to the use of 32-bit mainframe compiler technology that includes global optimization and sophisticated register use. NDP Fortran-386 generates native 80386 code that runs in protected mode under MS-DOS or UNIX V. The addressable memory available in the linear address mode is 4GB as opposed to the 640KB of DOS. $595.
MicroWay, P.O. Box 79, Kingston, MA 02364; 617/746-7341
CIRCLE 327 ON READER SERVICE CARD

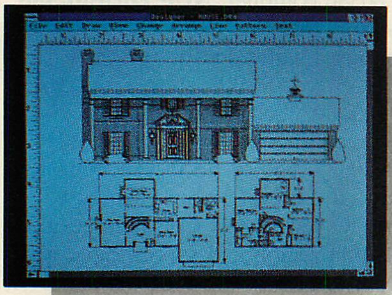
Micrografx, Inc., has begun licensing the **Micrografx Windows Development Libraries**, a comprehensive set of Windows development tools, and has also introduced an **Independent Software Vendor (ISV) Support Program** for third-party Windows developers. The development libraries consist of three runtime libraries: the Draw



Screen from PROGRESS version 4.0 from Progress Software

System running ZIM 3.0 from Zanthe Information

Library, the Extended Graphics Library, and the Utility Library. The Draw Library provides a flexible set of tools for creating and maintaining complex graphical images in a Windows application and provides compatibility with other Micrografx products—Designer, Windows DRAW, Windows GRAPH, and In*a*Vision; it assists developers in creating applications compatible with these programs. The Extended Graphics Library provides a number of extensions and improvements to Windows Graphics Device Interface (GDI) for applications running under Windows. The Utilities Library provides applications with a set of general tools useful for string manipulation, DOS I/O, buffer management, and dialogue-box support as well as other operations. The libraries also contain a sample



Screen from Micrografx Development Libraries

application, **Windows PORTFOLIO**, with its source code, which demonstrates how to use the libraries and includes source code for loading, printing, and copying Micrografx-compatible images. Licensing for the Windows Development Libraries is provided by Micrografx on a case-by-case basis; they will not be available to developers of products that directly compete with Micrografx's product line.
Micrografx, Inc., 1820 N. Greenville Ave., Richardson, TX 75081; 214/234-1769
CIRCLE 328 ON READER SERVICE CARD

DATABASE MANAGEMENT

Relational Technology, Inc. has announced the **INGRES Gateway** group of products, which provides an easy migration path from early-generation file management systems such as RMS and dBASE to distributed relational database environments such as INGRES. The **INGRES RMS Gateway** allows users to access RMS files in the Digital Equipment Corporation's (DEC) VAX/VMS environment using industry-standard SQL. The gateway provides ease of writing applications for RMS data in 4GL. Users also can take advantage of INGRES tools such as Query-By-Forms, Report-By-Forms, and Visual Graphics Editor to access, organize, and present RMS data. On a DEC VAXstation, $450; on a DEC VAX 8978, $24,000.

The **INGRES dBASE Gateway** allows users to run existing dBASE applications and new 4GL applications with the same data. Using industry-standard SQL, the gateway allows the user to access dBASE files in the DOS environment and take advantage of INGRES tools to organize and present data. $120.
Relational Technology, Inc., 1080 Marina Village Parkway, Alameda, CA 94501-9891; 800/446-4737; 415/769-1400
CIRCLE 336 ON READER SERVICE CARD

A relational database management system and fourth-generation language, **PROGRESS version 4.0,** has been announced by **Progress Software Corporation** (formerly Data Language Corporation). PROGRESS is also available on Digital Equipment Corporation's (DEC) VAX/VMS operating system, as well as ULTRIX, UNIX, XENIX, and DOS operating systems. Version 4.0 is transparently portable across all computing environments, allowing applications developed using PROGRESS to have the unique flexibility to run unchanged on multiple operating systems on over 125 hardware platforms. Version 4 also features support for C subroutines, security enhancements, ability to overlap windows in color, and roll-forward recovery. It has a fault-tolerant database engine that ensures the integrity of the database in the event of operator error or power, hardware, or software failure. $1,000 to $125,000 (varies with host computer).
Progress Software Corporation, 5 Oak Park, Bedford, MA 01730; 617/275-4500
CIRCLE 335 ON READER SERVICE CARD

A fourth-generation language database management system, **ZIM 3.0**, has been announced by **Zanthe Information, Inc.** Enhancements included in 3.0 include complete micro-to-mainframe portability without code changes, performance optimization in each operating environment, multiuser capabilities, import/export capabilities, rapid prototyping capabilities, complete debugging facilities, nested assignment expressions, CASE tools, SQL, multilevel security, and report painting.

In conjunction with the release of ZIM 3.0, Zanthe also announced the availability of ZIM on the IBM VM/CMS operating system and the release of **ZIM/DA 2.0** (ZIM Development Assistant), **ZIM SQL** (featuring SQL standard constructs integrated into the ZIM development environment), and **ZIMPLE** (an application module supporting end user ad hoc query and report generating). ZIM 3.0, $880; ZIM/DA 2.0, $380; ZIM SQL, $255; ZIMPLE, $380.
Zanthe Information, Inc., 1200-38 Antares Drive, Nepean, Ontario, Canada K2E 7V2; 800/267-9972; 613/727-1897
CIRCLE 337 ON READER SERVICE CARD

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High C - by Metaware	PC	Call
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AI Languages

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ARITY Prolog - full, 4 Meg		
Interpreter - debug, C, ASM	PC	$ 229
COMPILER/Interpreter-EXE	PC	$ 569
Cogent Prolog Compiler	MS	$ 179
MicroProlog Prof. Comp./Interp.	MS	$ 439
PC Scheme LISP - by TI	PC	$ 85
Star Sapphire	MS	$ 429
TransLISP - learn fast	MS	$ 79
TransLISP PLUS	MS	$ 149
TURBO PROLOG by Borland	PC	$ 69

Others: IQ LISP ($239), IQC LISP ($269)

Basic

BAS_C - economy	MS	$ 179
BAS_PAS - economy	MS	$ 135
Basic Development Tools	PC	$ 89
db/Lib	MS	$ 119
Exim Toolkit - full	PC	$ 45
Finally - by Komputerwerks	PC	$ 85
Inside Track	PC	$ 49
Mach 2 by MicroHelp	PC	$ 55
NetWorks by Exim	PC	$ 89
QBase - screens	MS	$ 79
QuickBASIC	PC	$ **69**
Quick Pak-by Crescent Software	PC	$ 59
Quick-Tools by BC Associates	PC	$ 109
Stay-Res	PC	$ 59
True Basic	PC	$ 79
Turbo BASIC - by Borland	PC	$ 69
Turbo BASIC Database Toolbox	MS	$ 69

FEATURES

Windows/386 by Microsoft-multitask standard DOS applications in separate 640K segments and access expanded memory. Toggle, run simultaneously, or foreground only. PC $ 149

Alsys ADA - DoD certified, version 3 for AT. Optimizing Runtime Executive, Multi-Library environment, informative error messages. PC, List: $2995

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Choosing an Operating System

Five or six years ago, the combination of a PC and Microsoft DOS was considered the epitome of microcomputing power. Today, however, developers and end users find the single-task, single-user environment of DOS restrictive, largely because of the 640KB memory limitation and inability to run more than one application at a time. IBM and Microsoft's new operating system, OS/2, has been heralded as a solution to these problems, but it is not the only answer.

The excitement stirred by OS/2 likely will give users and developers the momentum needed to break away from DOS, but they should realize that OS/2 might not be the best choice for their specific needs. Alternative products are available, and informed decision makers will want to examine them before choosing a direction. These products and their features are summarized in tables 1 and 2. In-depth reviews of several are provided in separate articles in this issue: "386 Operating Environments," Ed McNierney, p. 60, examines Digital Research's Concurrent DOS 386, The Software Link Inc.'s PC-MOS/386, Quarterdeck's DESQview 2.0, and Microsoft Windows/386; "The DOS–UNIX Union," William Tropp and Stephen Wright, p. 78, reviews Microport's add-on product to UNIX. Quantum Software Systems Limited's QNX was reviewed earlier ("Realtime Systems: A Message-Passing Executive," Gary Elfring, January 1987, p. 126).

THE RANGE OF FEATURES

When assessing alternative systems to DOS and OS/2, users and developers must consider what combination of features best provides them with the functionality they seek. Operating system features that are most sought today are application availability, multitasking, large address space, multiuser support, realtime capacity, files larger than 32MB, and graphics and communications support systems.

Application availability. What applications an operating system can run is of prime importance to a user. As alternatives to OS/2, systems such as UNIX or QNX can be worthwhile; a reasonable number of applications are available for such systems, especially in the UNIX environment. DOS compatibility is an important issue facing users and developers who want to run existing DOS applications alongside their new applications on an enhanced operating system without incurring the time and expense required in conversion. For those users whose current investment in DOS applications is considerable, an incompatible operating system might be out of the question.

For this reason, many operating environments allow DOS-executable files to be run without modification. Such compatibility is usually found in multitasking systems that allow one or more DOS tasks to run concurrently with native-mode software. In these systems, a subenvironment is created that looks and acts like DOS. The effectiveness of this subenvironment to run DOS applications varies with the implementation. Some environments do not

ILLUSTRATION • LESLIE CABARGA

Do not assume that OS/2 is the only answer to the question, "Which operating system do I use now?" This is definitely a multiple-choice question.

ED McNIERNEY

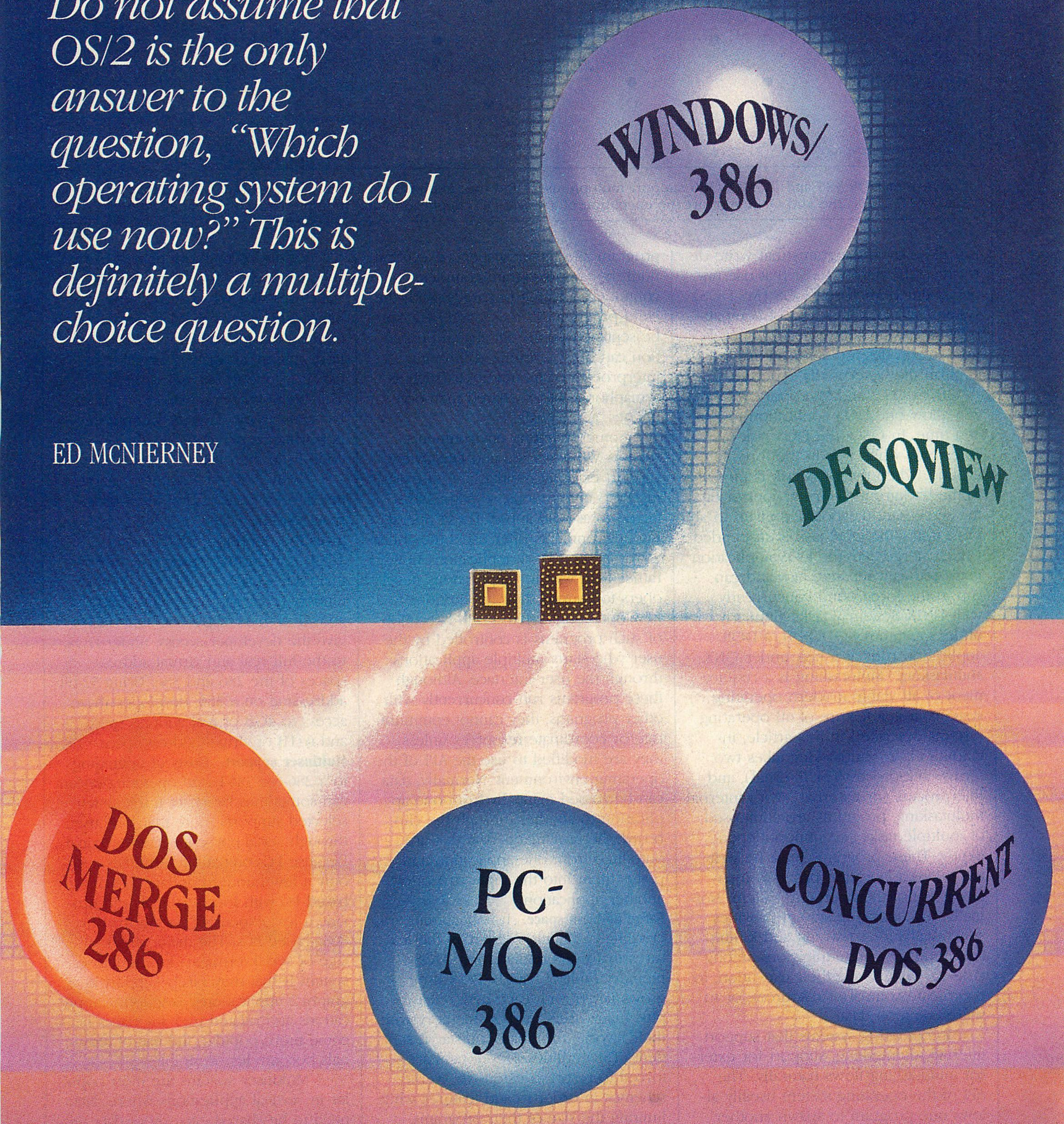

TABLE 1: *Alternative Operating Systems*

	OS/2		UNIX 286		UNIX 386		QNX		CONCURRENT DOS 386	PC-MOS/ 386
	Base	DOS Env.	Base	Merge 286	Base	Merge 386	Base	QDOS2		
Multitasking support	●		●		●		●		●	●
Multiuser support	○		●		●		●		●	●
Task greater than 640KB	●		●		●		●		●[a]	●[a]
Large linear addresses	○		○		●		○		○	○
Runs DOS applications										
Single	○	●	○	●	○	●	○	●	●	●
Multiple	○		○		○	●	○		●	●
Requires 80286	●		●		○		○		○	○
Requires 80386	○		○		●		○		●	●

● = *Yes* ○ = *No*

[a] *Using expanded memory.*

Concurrent DOS 386 and PC-MOS/386 support multiple users and the simultaneous execution of multiple DOS applications. Like OS/2, UNIX 286 and QNX support the execution of a single DOS application and multiple native-mode applications.

run ill-behaved programs that write directly to the hardware or that use undocumented Microsoft DOS (MS-DOS) system calls. The best test of compatibility is for the software developer or user to run desired applications and confirm they execute as expected.

Both OS/2 and Microport's Merge 286 allow one DOS application to run at a time. In OS/2, the DOS task executes only when it is in the foreground. When the DOS task is moved to the background—when control of the screen and keyboard is given to an OS/2 task—the DOS task is suspended. Under Merge 286, the DOS application is treated as a separate task and can run in the foreground concurrently with UNIX System V tasks. Similarly, under Quantum's QDOS II, a DOS application runs as a task under QNX.

Multitasking. Multitasking is a requirement of all viable modern operating systems; it is a feature of all operating systems described in this article, including OS/2. Multitasking takes two forms: intraprocess (or internal), and interprocess (or external). With internal multitasking, programs are composed of multiple tasks executing independently. These programs must be written to the application program interface (API) of the operating system. Normally, the operating system provides system calls for spawning and killing tasks, and for communications among tasks to synchronize their execution, to coordinate control of resources, or to share common data.

In operating systems that support internal multitasking, support for external multitasking flows naturally. The API of the operating system usually allows one program to spawn another program and either suspend execution until the child program completes or continue executing in parallel with the child program. Messages and data can be sent between programs and execution can be synchronized through interprocess communications such as semaphores, pipes, shared memory, queues, and signals.

Some operating environments, such as Windows 386 and DESQview, support external multitasking of existing DOS applications, sometimes referred to as "old apps." These operating environments offer users the ability to run several DOS applications now, rather than wait for applications developers to convert their applications to a new operating system's API. Execution of such programs is controlled by the user who starts multiple applications through the user interface. Although these programs run concurrently with other programs, they cannot communicate or coordinate resources unless they are modified to use the API of the operating environment. Normally, data can be passed manually from one application to another through the clipboard; the user marks data that are outputted from one application and pastes them into the input stream of another application.

Large address space. It is becoming increasingly difficult to cram all the features that users demand into DOS's memory limit of 640KB. DOS itself grows larger with each new release, plus many users load up memory with their favorite terminate-and-stay resident (TSR) utilities. Developers are forced to resort to extensive overlay schemes in order to add features while limiting the size of their programs.

Expanded memory delivers some relief, especially for handling large data structures like spreadsheets. The Enhanced Expanded Memory Specification and the Expanded Memory Specification version 4.0 make it possible to execute code in expanded memory. This bank-switching of memory is similar to using overlays yet without the performance penalty of loading overlay code from the disk.

Neither of these solutions allows the developer to exploit the address spaces of the 80286 or the 80386. OS/2 gives the developer access to the 286's 16MB real address space and 1GB virtual address space. So-called DOS extenders (Phar Lap's 386/DOS-Extender and AI Architects' OS/286 and OS/386 give the developer access, under DOS, to the full real and virtual address spaces of the 286 and 386. Using 32-bit addressing on a 386, developers have access to 4GB of real address space and 64TB of virtual address space.

Multiuser support. Costs of upgrading to a 286- or 386-based operating system can sometimes be offset if the system selected supports more than one user through serial-port-connected terminals. Because PC-compatible terminals cost only a few hundred dollars, a 386-based PC with four terminals can provide a less expensive system than five 8086-based PCs. The major disadvantage of serial terminals in a multiuser system is that they rarely support PC graphics applications; as graphics applications and related user interfaces become more popular, the use of terminals become less desirable.

Multiuser systems are most popular in vertical applications where data need to be shared. Sharing of data re-

TABLE 2: *Application Managers, DOS Extenders, and EMS*

	APPLICATION MANAGERS		DOS EXTENDERS		EXPANDED MEMORY	
	DESQview 2.0	Windows/386	286	386	LIM EMS 4.0	QEMM 4.0
Multitasking support	●	●	○	○		
Multiuser support	○	○	○	○		
Task greater than 640KB	●[a]	●[a]	●	●	●	●
Large linear addresses	○	○	○	●	○	○
Runs DOS applications						
Single	●	●	●	●	●	●
Multiple	●	●	○	○	●	●
Requires 80286	○	○	●	○	○	○
Requires 80386	○	●	○	●	○	●

● = *Yes* ○ = *No*

[a] *Using expanded memory.*

DESQview and Windows/386 work with DOS to manage the execution of multiple applications. DOS extenders are used to build protected-mode applications that run under DOS. LIM EMS products allow DOS applications to be larger than 640KB.

quires that the operating system strictly control access to files. A systems administrator establishes an account for each user, which allows the user to log on to the system and defines what file privileges that user will enjoy—which files he will be allowed to read, write, and execute. The operating system then monitors file activity, enforcing the privileges granted or denied each user.

Another consideration in choosing whether or not to go with a multiuser system is the cost of a systems administrator to back up the system, service user requests, and maintain user accounts and security features. OS/2 has no multiuser support.

Realtime capacity. Another feature desired in many vertical applications, such as process control or point-of-sale, is realtime response. Not only does realtime response require multitasking, but it also requires that tasks be prioritized and that the task scheduler preempt an executing task when a higher-priority task becomes ready. Since OS/2 has no guaranteed task-switching time, it makes a poor candidate for critical realtime applications. On the other hand, QNX, with its promised worst-case task-switching time of 200 microseconds on a 10-MHz PS/2, guarantees the response time that is necessary for realtime applications.

Files larger than 32MB. DOS's file system is serviceable, but suffers from limitations that can be severe in some environments. For example, the 32MB disk volume limitation hinders large databases. OS/2 Standard Edition 1.0 retains the DOS 32MB barrier, but Microsoft has announced that the barrier will be removed in a later release of the operating system.

Methods exist to improve file systems, but by necessity they are at the expense of DOS compatibility. Operating systems that provide such improvement might supply a DOS file import/export facility for facilitating transfers between the two systems.

Graphics support. Built-in operating system graphics services are valuable. As the number and complexity of PC graphics displays and printers increase, the need among developers for device-independent graphics grows as well. Such graphics features, however, are often neglected in an operating system's design so that developers must either use the low-performance PC BIOS routines provided or they must develop their own routines.

OS/2's Presentation Manager provides a graphics user interface as an integral part of the operating system, but the software will not be available until OS/2 Standard Edition 1.1 is shipped in November 1988. For DOS, Microsoft Windows and similar products are available for use as graphics interfaces. Designers of systems that are not DOS-compatible should consider providing a standard graphics system as part of their product; UNIX systems, for example, are served by X-Windows, which is still relatively unknown but growing in popularity.

Communications support. In addition to serial communications necessary for multitasking systems, more general modem and network communications can be built into PC operating environments. Applications software needs to work with files and message buffers without concern for whether they are local or remote—connected via cable, microwave, or modem. Data transfer must be independent of system technology or the operating systems of the communicating computers.

Communications support can be categorized as either standard or optional and implemented separately. Most important to users is that new devices are supported via software-transparent system upgrades after the original system is installed.

SWEEPING APPROACHES

Although OS/2 offers some of the desired features, it does not support all features potentially available to users with the 386 processor, although it runs on either 286- or 386-based computers. Another shortfall might be that OS/2 has just recently been released, while many other options have been available for some time.

Software designers attempting to provide OS/2-equivalent features to DOS users are taking three basic routes: new or enhanced operating systems, applications managers, or applications environments.

Enhanced operating systems. Several years ago, the number of viable choices for PC operating systems was small. IBM's continued endorsement of MS-DOS made it the overwhelming favorite, but small pockets of support for Digital Research, Inc.'s CP/M and University of California San Diego's (UCSD) p-System products remained. Over time, UNIX-compatible systems appeared and gathered a noticeable following with the introduction of the PC/AT. Although DOS remains the most popular operating system for IBM-compatible machines, the last several months have seen an explosion in the number of viable alternatives being of-

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fered by competing systems software developers. OS/2's introduction in April 1987 legitimized the scramble. Because user investment in DOS software is great, huge deviations might threaten market acceptance unless these new operating systems provide sufficient new value or new software developer support to compensate.

Newly released enhanced operating systems include The Software Link, Inc.'s PC-MOS/386, Digital Research, Inc.'s Concurrent DOS/386, and, of course, OS/2. Both of these operating systems were designed to overcome limitations of DOS and to add new features to improve upon features found in DOS. In addition, Concurrent DOS/236 also provides CP/M compatibility.

An operating system's design is intimately tied to the processors it supports. The current DOS environment is based on the Intel 8086-type processors (including 8088, 80186, and 80188) found in the IBM PC, XT, Portable, Convertible, and compatible computers as well as the IBM Personal System/2 Models 25 and 30.

Intel 8086-type processors provide no hardware support for multitasking, memory protection, or other features associated with sophisticated operating systems. Nevertheless, some developers squeeze considerable functionality from the 8086 and they can simulate, with varying degrees of success, the features provided in hardware from the more powerful processors.

OS/2 itself cannot run on 8086-based machines; therefore, operating systems built on these machines are not considered OS/2 alternatives. However, these systems might provide added functionality over DOS for owners of current PCs who want to avoid the expense of upgrading to a computer that runs OS/2.

The complex features demanded of operating systems today require either 286- or 386-based machines, including AT, XT/286, and AT-compatibles as well as PS/2 Models 50, 60, and 80.

OS/2 is built on the 286 processor. While in protected mode, the processor offers task management, limited virtual addressing, and segment-based protection, and it is this environment that OS/2 effectively exploits. The 286 processor has some deficiencies that OS/2 is forced to pass on to its applications. The 64KB maximum segment size still requires the developer to manage multiple code and data segments. Support for 8086 software is limited to real mode; although the 286 can be switched to protected mode under software control, a return to real mode requires a hardware reset and it is undesirably slow.

The newer 386 processor supports enhanced memory protection and execution of multiple 8086 applications, with each application running in its own virtual 8086 machine, isolated and protected from other applications. 386-based computers support page-mapped virtual memory systems, improved task management facilities, large linear address space (maximum segment size is 4GB), 32-bit operations, and an I/O protection bit map to prevent direct access of devices by applications.

One shortcoming of OS/2 is that it treats the 386 as it does the 286, without tapping the added features of the newer processor.

Although the installed base of 386 computers is still relatively small when compared to the 286, the 386 is currently the most powerful and significant member of the Intel processor family (see "Upward to the 80386," Caldwell Crosswy and Mike Perez, February 1987, p. 50). One shortcoming of OS/2 is that it treats the 386 as it does the 286, without tapping the added features of the newer processor. Competing vendors can readily exploit this OS/2 weakness by providing 386-specific products. For users planning to upgrade hardware, 386-based machines might be better choices than 286-based ones because they offer significantly increased speed and functionality with only a small increase in cost.

Control programs (application managers). Control programs operate under an existing operating system but radically change its character. Products such as Windows/386 and DESQview run under DOS, but they provide a new user interface, and they exploit the virtual 8086 mode of the 386 processor to run multiple DOS applications concurrently. Such control programs help to ease DOS's memory limitations by supporting the Lotus/Intel/Microsoft expanded memory specification (LIM EMS). In addition, DESQview/386 will run applications that are written for Phar Lap's 386/DOS-Extender that run in protected mode on the 386.

Application environments. Application environments are those that last only for the duration of a single program. These environments are based on the premise that applications interact with an operating system only for clearly defined services and that the operating system is oblivious to the state of the processor when it is not active. DOS operates in either real or virtual 8086 mode on a 386-based machine, but if an application switches into and out of protected mode between system calls, DOS is not affected.

Control software such as Phar Lap's 286 and 386 DOS Extenders and AI Architect's OS/286 and OS/386 provide such functionality, constructing an interface between the application and the operating system.

These DOS extenders allow an application to exploit the address space of the 286 and 386 processors while still running under DOS. The advantage is that the user is not required to buy a new operating system in order to run the enhanced application. Once the application receives control, it is in a full protected-mode environment; because interaction with DOS is trapped by control software, the processor can return to real mode for the length of the required system call.

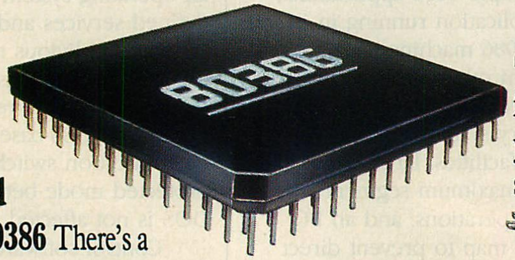
THE CHOICE IS YOURS

No existing products (operating systems or extensions) offer all of the improvements over DOS that have been described here. (See tables 1 and 2 for a summary of features found in current operating systems, application managers, DOS extenders, and EMS.) Additional products are expected as software designers hasten to take advantage of the opportunities that exist, including those that result because of shortcomings in OS/2.

Deciding whether another system offers sufficient features to warrant use over OS/2 is a complex and user-specific process; OS/2 is a sophisticated operating system that excels in many areas. Perhaps more important to developers and users is the fact that OS/2 has been endorsed by IBM, Compaq, Tandy, and other computer manufacturers, a level of support and commitment not yet shared by any alternative. However, for users whose requirements differ from those of the PC mainstream, more suitable and effective solutions than OS/2 might already exist.

Ed McNierney is principal engineer at Lotus Development Corporation. His focus is on developing graphics hardware interfaces.

A Number of Reasons A Number



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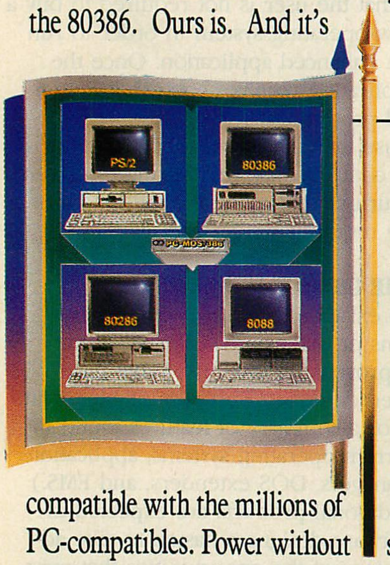

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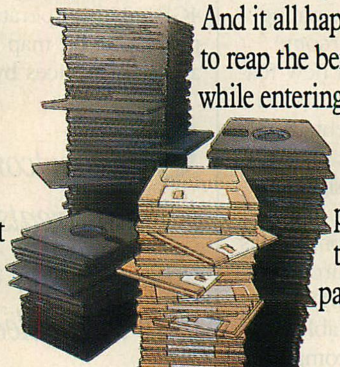

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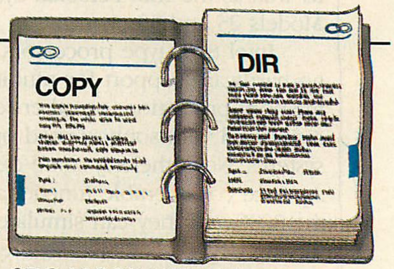
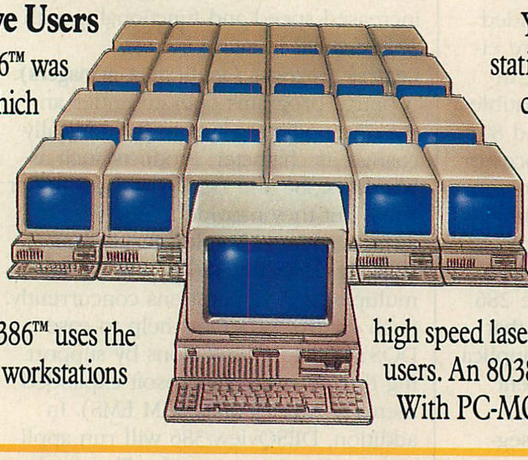


Just as you don't have to learn a whole new array of software to take advantage of PC-MOS/386,™ neither do you have to learn an entirely new set of commands.

Instead, the system builds on the knowledge you already have. "COPY" still copies files, and "DIR" still gives you a directory listing. As you might expect, we didn't stop there. There's a wealth of features that have strengthened the commands you know, making them more powerful and easier to use.

3. One, Five, Up to Twenty-five Users From the beginning, PC-MOS/386™ was designed as a versatile operating system which could support twenty-five users as easily as it supports one. The system comes in single, five, and 25-user modules, so you're able to start with what you need and expand when you're ready.

In a multi-user setting, PC-MOS/386™ uses the computing power of the host PC to drive workstations linked to standard RS-232 ports.

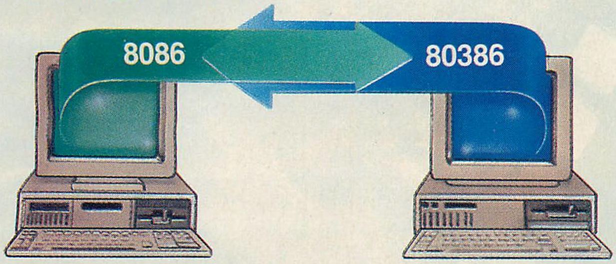


You can choose from a variety of workstations. Mix and match dumb terminals costing under $500 each with PCs and PS/2s running our terminal emulation software.

All of the host's resources can be shared. Programs, data, hard disks, tape backup units & printers (including high speed laser printers) are suddenly available to all users. An 80386-PC has minicomputer potential. With PC-MOS/386™ you can "mini" your micro.

# of Users Will Choose PC-MOS/386.™

6. Concurrently Supports Virtual 8086 and *80386 32-Bit Mode*

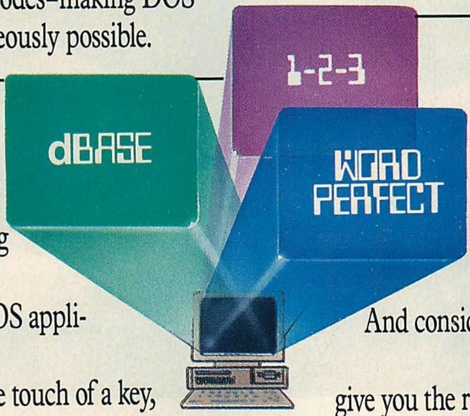


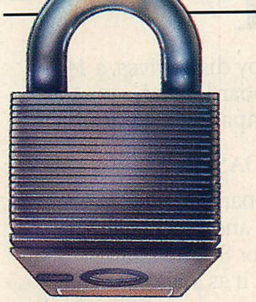
80386-based PCs & PS/2s are dual-personality computers. To run DOS programs, they act as PCs with a 640K memory limit. But to take advantage of their minicomputer capacity, they operate in true 80386 mode which lets them address up to four gigabytes of memory. PC-MOS enables the 80386-host and its workstations to independently switch between these modes–making DOS compatibility and 80386 power simultaneously possible.

7. Multi-Tasking

While it's true you could look elsewhere for multi-tasking, why would you want to? The *other* multi-tasking operating system is not now, nor is it planned to be, multi-user. It won't even run multiple DOS applications in multi-tasking mode.

Now consider PC-MOS/386.™ At the touch of a key, you can switch between up to 25 different tasks. And if you have workstations connected to a host, they get multi-tasking, too. Finally...a system that won't hold you back.



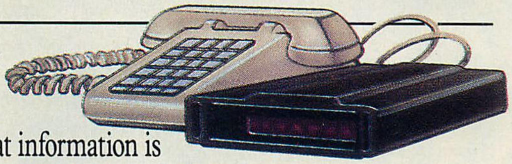


8. File/Record Locking and Security

When you decide to implement either a network or a multi-user system, there's a two-fold problem which must be solved: protecting your work from accidental misuse and securing it from intentional theft.

PC-MOS/386™ solves both aspects of this problem. Password protected security allows you to assign file, directory, and task access to each user. Plus, files and records are locked using either PC-MOS' proprietary system or NETBIOS emulation.

9. Remote Access



It's been said that information is power...which makes PC-MOS/386™ a deadly weapon to your competition. Imagine on-the-road salespeople being able to file call reports and access your latest inventory data. Picture executives being able to access your corporate database from across the country, or around the world–giving them the information they need, when they need it.

Visualize branch offices tapping time-critical data with nothing more than a modem and a workstation. Working at a home office in the evening or over the weekend suddenly gets awfully productive. And that makes good business sense. The kind of sense you can't afford to be without.

10. The Price...

As you evaluate operating systems, ask yourself if it's reasons you're considering...or rhyme. Ask if you're getting a system for tomorrow, or one that was made for yesterday. See if you're being forced to buy new hardware because of *their* software.

And consider this.

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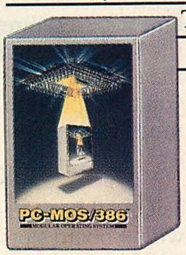

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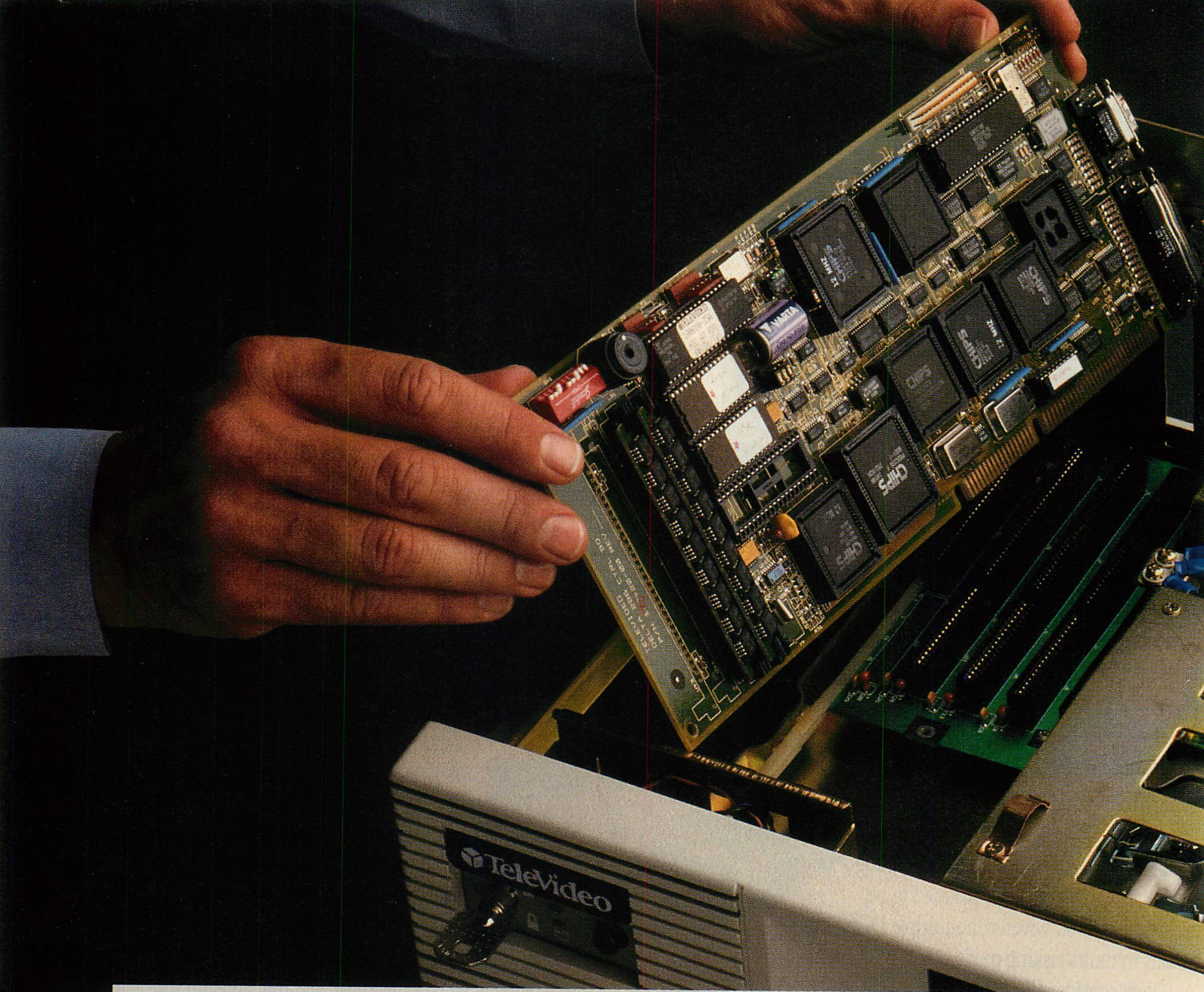
PC-MOS/386™

MODULAR OPERATING SYSTEM

THE SOFTWARE LINK

CIRCLE NO. 196 ON READER SERVICE CARD



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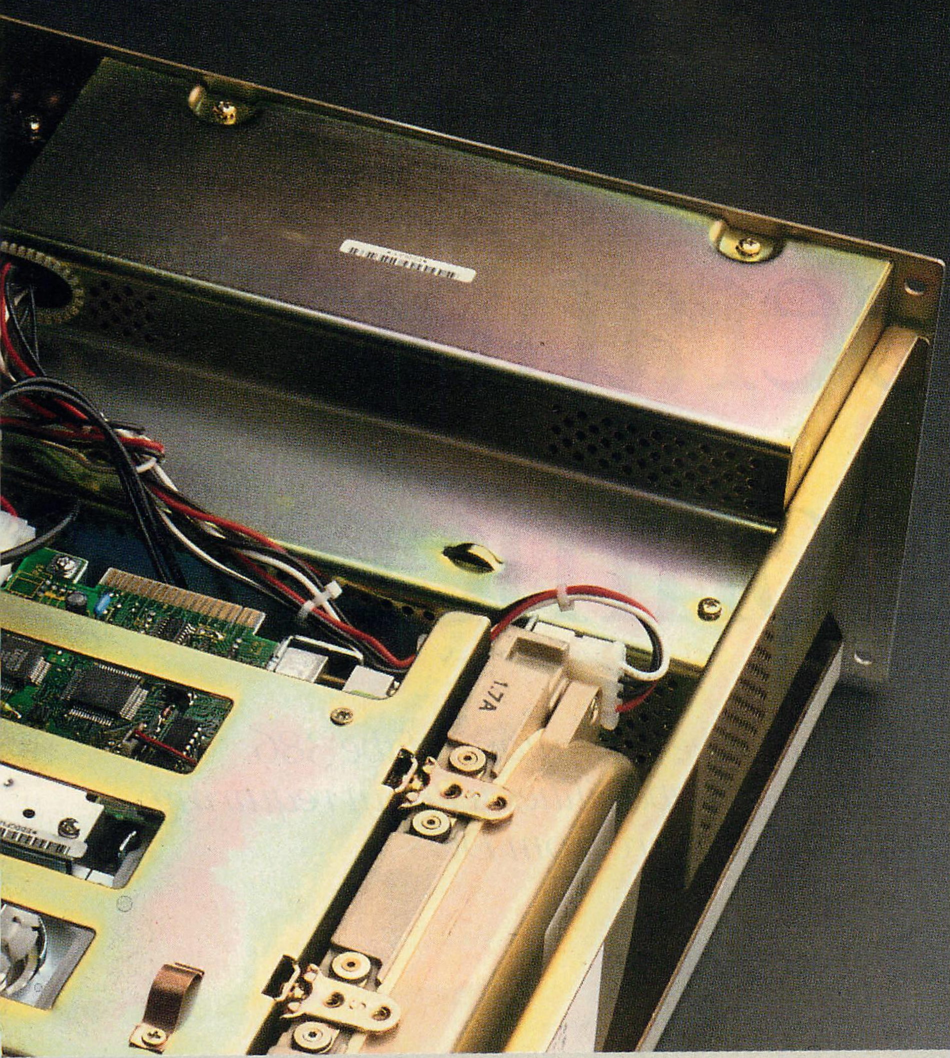
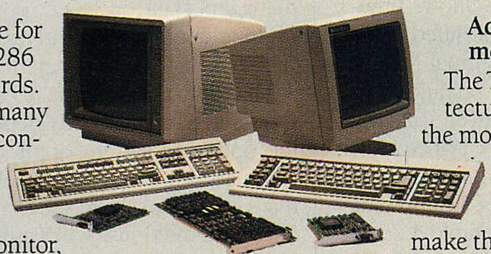


Kinds Of Possibilities.

and is suitable for either the 80286 or 80386 boards. One of your many options is to configure it as a 386 and add an EGA standard color monitor, 80387 math co-processor, optical mouse, a hard disk and the right software to get a powerful 386 engineering workstation. It's also the right size for a LAN file server or multi-user host system.



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386 Operating Environments

Control programs that take advantage of the 386 processor give users increased capabilities without requiring a premature departure from DOS.

ED McNIERNEY

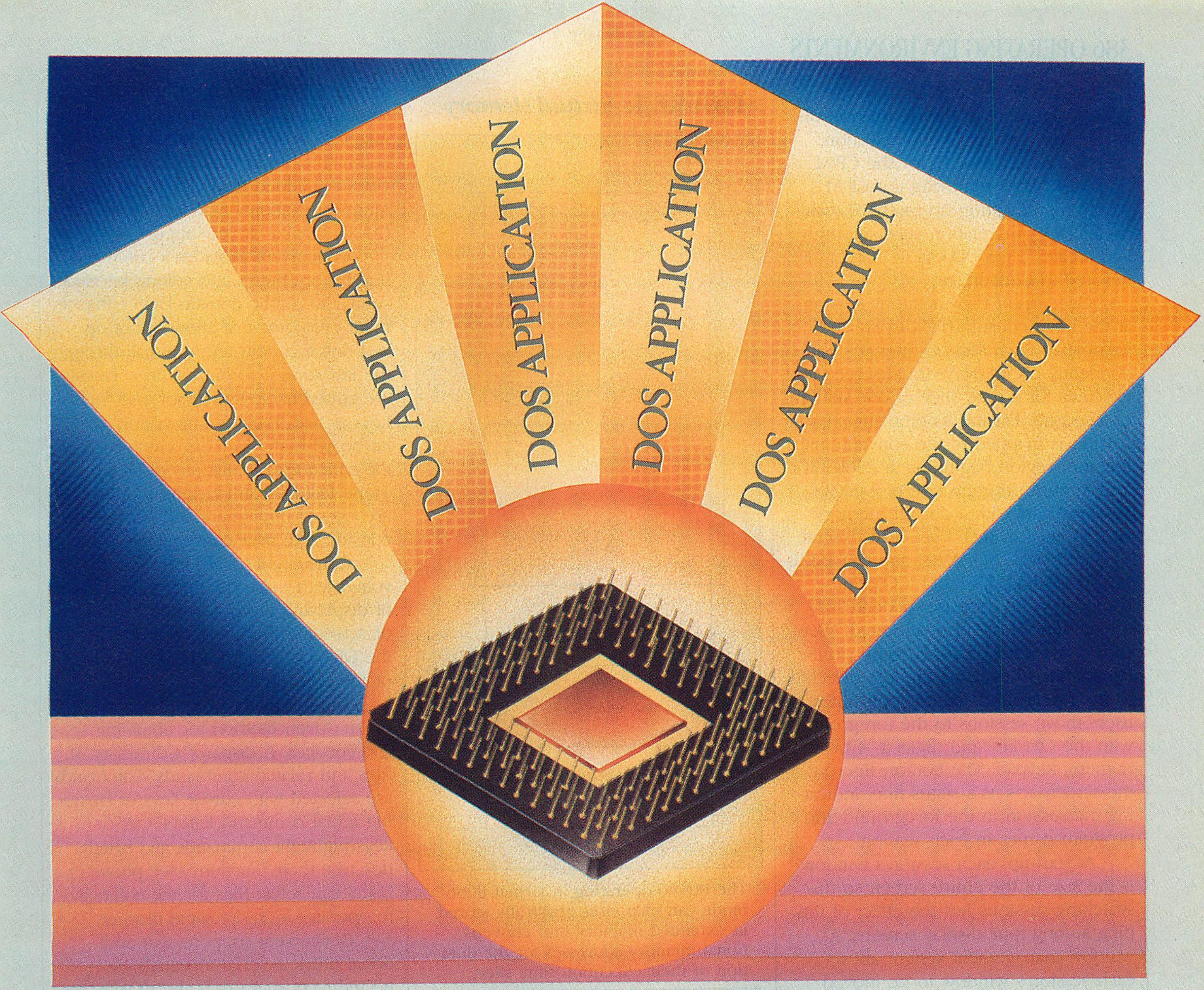
An important ingredient for attaining multitasking, virtual memory, and multiuser features is the 80386-based computer introduced more than a year ago. Four products, Digital Research Inc.'s (DRI) Concurrent DOS 386, The Software Link's PC-MOS/386, Microsoft's Windows/386, and Quarterdeck's DESQview 2.01, provide the necessary brains to exploit the power of the 386. DOS, with its 640KB memory limitation, and OS/2, which runs the same on 386 machines as on 286 models, do not.

The strength of Concurrent DOS, PC-MOS/386, Windows/386, and DESQview lies in their use of the 386 processor's virtual-8086 mode and their DOS compatibility. Like other products that offer advanced computing features (see "Choosing an Operating System," Ed McNierney, this issue, p. 50), they build on DOS, rather than require rewriting of applications.

To take advantage of the 386, Concurrent DOS, PC-MOS/386, Windows/386, and DESQview time-share the processor among tasks and use memory-mapping capabilities to map tasks physically stored in extended memory into conventional memory addresses for the duration of their time slice (see figure 1). With the 386's virtual device management capabilities, this allows time-shared execution of unmodified DOS tasks (see the sidebar, "Virtual Machines on the 80386," p. 66, and "Upward to the 80386," Caldwell Crosswy and Mike Perez, February 1987, p. 51). Each product has its own application strengths and weaknesses. Features of all four are compared in table 1.

Concurrent DOS 386 and PC-MOS/386 are both multitasking and multiuser operating systems in their own right that replace rather than enhance DOS. They do not require purchase or use of DOS and are free to provide features that DOS inherently cannot provide. These systems support multiple users through applications run on remote terminals connected to serial ports on the host 386-based computer (PC-MOS/386 also runs on 286- and 8088-based machines). Concurrent DOS 386 supports 2 local or remote terminals; PC-MOS/386 supports 24.

Windows/386 and DESQview 2.01, on the other hand, are applications managers built on DOS, providing multitasking (but not multiuser) capabilities and allowing users to operate in a 386 control environment. By structuring themselves as shells dependent on the operating system, applications managers are inherently compatible with that operating system (see "Protective Shells," Directions, Will Fastie, October 1987, p. 9). They enhance normal PC single-monitor operation through a windowing environment capable of simultaneously displaying text and graphics applications. These products also provide users with a fallback mechanism; if a DOS application does not operate properly under the applications manager's control, it can always be run under DOS directly.



CONCURRENT HERITAGE

DRI has developed a long line of operating systems: first the commercially successful CP/M for Z-80 and 8088 microprocessors, then CP/M-86 and Concurrent DOS, and now Concurrent DOS 386 (see "Concurrent PC-DOS," Don Awalt, March 1985, p. 45 and "Concurrent Environments," Don Awalt, December 1985, p. 52). The company has attempted to maintain compatibility among its own operating systems almost to the point of absurdity. For example, users of Concurrent DOS 386 can read and write CP/M disks and set up a CP/M hard disk complete with user numbers and logical drive features supported by CP/M. Although a nice gesture to earlier customers, the support is not necessary in a 386-based system and only serves to confuse installation and setup of Concurrent for users who need no support for CP/M.

Getting acquainted. Concurrent is shipped on five 360KB 5.25-inch diskettes containing a bootable version of the operating system, a set of operating system programs, and user utilities. It requires a Compaq Deskpro 386, an IBM PS/2 Model 80, or a 100-percent compatible computer with at least 512KB of memory for operation; a hard disk is recommended.

Documentation assumes users are familiar with DOS. More than that, in places, it actually advises the use of DOS commands for operations not supported in Concurrent.

For users with a DOS-formatted hard disk, installation of Concurrent is simple (the start-up screen tells users to press the F10 key to install). Eleven operating system files are copied to the hard disk's root directory. The system creates the subdirectory CON-DOS and copies Concurrent's user programs to it. Instead of directly booting Concurrent from the hard disk, DOS remains intact and the AUTOEXEC.BAT file asks users whether or not Concurrent is to be loaded. The system then returns to DOS or boots Concurrent. CONFIG.SYS on the DOS system must not specify that a device driver automatically enter protected mode when loaded, as Compaq's expanded memory manager (CEMM) does if the ON option is set. If this happens, Concurrent resets the system instead of loading itself.

If the hard disk has not been partitioned for DOS, the automatic installation procedure will hang the system. Users must boot the system from the installation diskette without running the automatic installation program and then run the HDMAINT program, which is not on the install diskette but on a second distribution diskette.

Concurrent supports two hard disks, each with four partitions that can be formatted for DOS or CP/M and can be 512MB in size. For this review, a hard disk was set up as a single CP/M volume, and the HDMAINT program performed an apparently thorough surface analysis while formatting the disk. Although the system can be set up on DOS hard disks C:, D:, E:, and F:, CP/M

ILLUSTRATION • LESLIE CARBARGA

choices are D: through G:. Because drive assignment of the destination disk is supplied through menu selection, users cannot choose C: for the CP/M boot disk. After removing the CP/M partition and setting up the hard disk under DOS, installation runs smoothly and creates a truly bootable hard disk devoted to Concurrent.

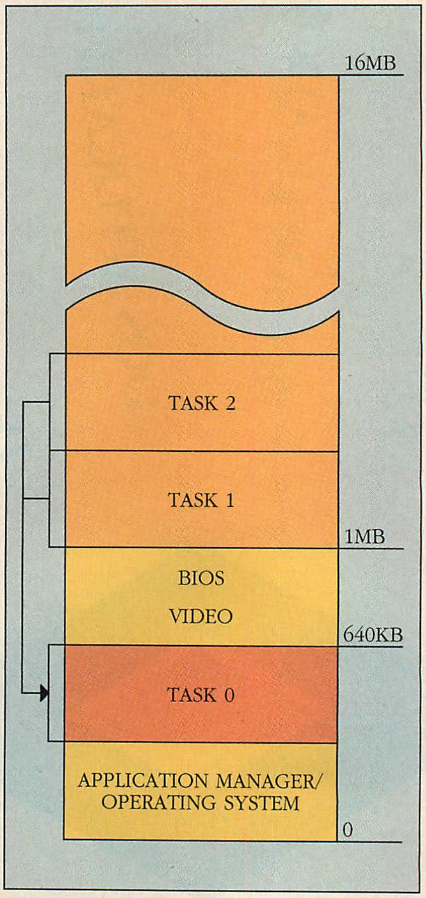
Concurrent provides four sessions at the main console (PC display and keyboard). Each session operates independently on its own virtual screen and executes for a time slice of one-sixtieth of a second. During its time slice, each session is mapped to the conventional memory region beginning at 256KB for a maximum program size of 348KB. Sessions start with a default memory allocation of 128KB. Users can execute the commands ADDMEM and COMSIZE before loading .EXE and .COM files, respectively, to increase or decrease the amount of memory allocated. (See table 2 for a list of Concurrent-specific commands.) Keyboard input is directed to the foreground screen at all times; users move sessions to the foreground with the Ctrl key and digits 1–4 on the numeric keypad. The bottom line on the screen acts as a status line, indicating the session in the foreground and program names in each session.

At start-up, each session's window is the size of the entire screen so that switching sessions has the effect of flipping among four display screens. A window management system allows each session's window to be moved and sized and to have its own foreground and background colors. Default operation of the system can be changed so that all four sessions are partially visible at the same time.

Window layouts are defined by a command line or the WMENU interactive utility. Once WMENU is installed, users can press the Ctrl key and the + key on the numeric keypad to switch the bottom status line to a WMENU prompt line. Window positions, sizes, and other attributes are set interactively. The keyboard interface, however, is awkward, and the utility should, but does not, provide interactive mouse support. Window definitions are saved in WSETUP.BAT, using the WMENU WRITE command. WSETUP.BAT must be executed each time the system is initialized to restore the window layout. The user executes this file in order to set up the windows.

Because most DOS applications are not designed to be run in small windows, Concurrent provides each window with a cursor tracking option.

FIGURE 1: ***Virtual Memory***



The 80386 operating in virtual 8086 mode can map tasks physically stored in extended memory into conventional memory addresses for the duration of their execution time slice.

This permits automatic scrolling of a session's virtual screen; the display row containing the cursor is always visible in the window. Each session has its own start-up file (an AUTOEXEC.BAT equivalent). This allows path and window setup and other configuration activities to be performed automatically each time the system is started. The start-up files are named STARTUP*x*.BAT, where *x* is the session number.

Concurrent DOS 386 supports expanded memory boards. It also has a built-in driver that uses 386 paging hardware and extended memory to simulate expanded memory.

Using Concurrent. At system start-up users have the option of loading Concurrent DOS 386 or the machine's native DOS, if present. If they select Concurrent, users can press F10 to see the start-up menu or Esc to enter Concurrent's command-line interface.

The interface is similar to DOS with a few improvements. Concurrent's video routines are faster; directory listings and TYPE files scroll quickly and smoothly on IBM's Enhanced Graphics Adapter (EGA). This performance is commendable in that Concurrent provides the added flexibility of built-in American National Standards Institute (ANSI) display driver support.

Concurrent provides a command-line history buffer and editing interface similar to public domain DOS enhancement programs that allow use of up and down cursor keys to scroll through the last several command lines. Lines are edited using the cursor and control keys as with BASIC's line editor. The keyboard buffer is large, eliminating the type-ahead limitations of DOS. These features, still lacking in MS-DOS, are easy to implement and provide considerable user convenience.

Concurrent's start-up menu, invoked with F10, offers users the choice of displaying the disk subdirectory tree or activating the file or print manager, the DR EDIX editor, a card-file utility, or the help utility.

The file manager is a convenient menu-driven method for obtaining system services. It displays a directory of files and related commands. Commands are selected with cursor keys or by typing initial command letters. Cursor keys highlight commands and briefly describe their functions (see photo 1). Users can select files for the command to operate on in the same manner.

Concurrent supports two additional users at serial terminals connected to ports COM1: and COM2:. Sessions that run at these remote terminals are not supported by the window manager interface and cannot be viewed at the main console. Start-up files for the terminals are called STARTUP5.BAT and STARTUP6.BAT.

Use of remote terminals is not documented well. The four-page READ.ME file provides cursory information for setting up multiuser system terminals. SETUP and SETPORT, two menu-driven configuration utilities, allow the two serial ports to be configured and dedicated to remote terminals or serial printers. Remote terminals cannot be transparent to user applications that run on them; applications must be aware that they are running on terminals and use appropriate ANSI (or terminal-specific) cursor positioning and text-output commands.

Concurrent compatibility. Concurrent suffers from a few compatibility problems. It lacks DOS version 3.x compatibility in interpreting program path names. Although it supports a search path, programs not on the path cannot

TABLE 1: *Comparison of Features*

	OPERATING SYSTEMS		APPLICATION MANAGERS	
	DIGITAL RESEARCH, INC.	**THE SOFTWARE LINK**	**MICROSOFT**	**QUARTERDECK**
PRODUCT	Concurrent DOS 386 1.1	PC-MOS/386 1.02	Windows/386 2.01	DESQview 2.01
CONCURRENCY				
Concurrent users	3	25	1	1
Concurrent tasks	255	99	32	256
MEMORY MANAGEMENT				
Minimum memory recommended	512KB	512KB	1MB	640KB
Maximum program size (EGA)	348KB	580KB	575KB	535KB
Disk swapping	○	○	○	●
Code/data sharing	●	●	●[a]	●
Expanded memory	●	●	●	●
USER INTERFACE				
Text windows	●	●	●	●
EGA graphics windows	○	○	●	○
Command-line interface	●	●	○	●
Mouse support	○	○	●	●
Expanded keyboard buffer	●	●	●	●
Macros	○	●	○	●
FILE SUPPORT				
File sharing	●	●	●	●
Logical disks greater than 32MB	●	○	○	○
OTHER FEATURES				
PIFs	○	○	●	●
Cut and paste	○	○	●	●
Print spooling	●	●	●	○
DOS level	2.x	3.2	3.3	3.3
Developer's toolkit	●	●	●[b]	●
Companion applications	○	○	●	●

● = *Yes* ○ = *No*

[a] *Among Windows 2.0 applications only.*
[b] *Windows 2.0 Software Development Kit.*

Concurrent DOS 386 and PC-MOS/386 are DOS-compatible multiuser, multitasking operating systems; DESQview and Windows/386 are both applications managers that work with DOS to allow a single user to run multiple DOS applications.

be run by specifying the path name (consider C:\BIN\MYPROG, for example). This is a glaring omission.

Concurrent's support for character-based DOS applications is generally good; Microsoft's software development tools and Borland's SideKick and Turbo C all run without problems. Datastorm Technologies' communications program, Procomm, ran properly in one session, but an attempt to force a serial port conflict by running it in two sessions caused the system to beep and terminate the second session.

Copy-protected software and software with multiple text pages experienced problems. Lotus 1-2-3 release 2.0 cannot be installed or run on a 16-MHz 386-based system but runs well on 386 computers that allow the processor clock to be slowed to 8 MHz. Some 386 add-in boards for the AT, including Orchid's Jet 386, run exclusively at 16 MHz. Their manufacturers recommend that timing-dependent tasks such as Lotus 1-2-3 installation be run on the AT's 286 running at either 6 or 8 MHz. This is hardly a viable option if the timing-dependent task is a process running under Concurrent.

File security is provided using a password scheme. The FSET command is used to implement password protection on a disk volume, and to set passwords for access to individual files.

Concurrent does not properly handle text-page switching. Some text-based applications, such as Solution Systems' BRIEF editor, can detect a video adapter that allows multiple pages of text. When using such adapters, the editor switches to an alternate page for operation; this feature allows rapid restoration of the original DOS session screen after the editor is terminated. Concurrent, however, keeps the screen display on the original command-line page. This properly positions the cursor on the screen but prevents text output. The only way to make BRIEF work is to direct it to avoid using the alternate pages of video memory.

Graphics applications are also troublesome under Concurrent. With the exception of DRI's GEM graphics user interface, no graphics support appears in the documentation. When using an EGA and enhanced color display, a simple IBM Color Graphics Adapter (CGA) application running in black-and-white high-resolution mode appears blue on a solid-white background. Concurrent allows only one graphics application, including GEM, to be run at a time. EGA graphics can run only in a full-screen window. As applications become more graphics-oriented, Concurrent's lack of full support becomes more of a hindrance.

To its credit, DRI includes an insert on using 35 popular DOS applications under Concurrent that includes

setting memory requirements and the extent of multiple-copy support. Some applications are severely limited in that they cannot be run in mapped memory, and many applications can be active only in one session at a time. Multiple copies of BASIC cannot be run; thus, multiple programs written in BASIC (such as Peachtree's General Ledger) cannot be run simultaneously. Because users are not always aware of an application's need for BASIC, unexpected problems can arise.

Concurrent's approach to machine virtualization is generally limited. Concurrent creates a virtual memory space for each DOS application but goes no further in supporting virtual hardware operation. As a result, applications directly writing to graphics memory, specifically manipulating interrupt vectors, or operating at almost any other hardware level, are likely to have difficulty running under Concurrent.

DRI has announced release 2.0 of Concurrent DOS 386. This enhanced version supports larger task size (greater than 512KB), provides DOS 3.3 compatibility, and dual-session support on remote terminals. Display of EGA graphics in a window also is supported, but not for multiple windows.

Concurrent DOS 386 provides software developers with interprocess and intertask communication facilities that can be used for applications written only for Concurrent. The product is an excellent base for building in-house multitasking and multiuser character-based systems. But for users hoping to run multiple DOS applications with minimum effort and little or no risk, Concurrent does not provide needed flexibility and support.

TABLE 2: ***Concurrent DOS 386 Specific Commands***

COMMAND	PURPOSE
8087	Indicates that a program uses the coprocessor
ADDMEM	Increases memory size for .EXE programs
AUX	Selects auxiliary port 0 or 1
BANK	Controls program mapping to extended memory
CARDFILE	Stores and retrieves names and addresses
CHSET	Changes the command header of .CMD files
COMSIZE	Sets memory size for .COM programs
COPYMENU	Copies menus from one file to another
DELQ (ERAQ)	Deletes files, upon confirmation
DREDIX	Creates and edits text files
DSKMAINT	Formats, copies, and verifies diskettes
EDITMENU	Creates, modifies, and deletes menus
FM	Allows commands to be selected from menus
FSET	Sets file and drive attributes and protections
FUNCTION	Assigns function and window switching keys
HDMAINT	Performs disk partition and verification services
HELP	Explains Concurrent commands
INITDIR	Formats CP/M directories
LOAD386	Starts Concurrent from DOS
ORDER	Changes the command file search order
PIP	Copies files between directories and devices
PRINTER	Changes the current printer number
PRINTMGR	Controls the printing of files
RETURN	Resets the system
RUNMENU	Runs a menu
SDIR	Shows director and file status information
SETPORT	Configures the serial ports
SETUP	Modifies system characteristics
SHOW	Displays information about disk drives
STOP	Terminates a program
SUSPEND	Suspends a background program
SYSDISK	Shows/sets current system disk
USER	Changes user number on CP/M media
VSET	Prevents an application's use of specific interrupts
WINDOW	Shows and modifies window characteristics
WMENU	Provides interactive manipulation of windows

Concurrent has many commands in addition to those of DOS. They are primarily for allocating resources for multitasking and for providing CP/M media-related services. Commands also are provided for using and manipulating the menus.

MODULAR SYSTEM

The Software Link's PC-MOS/386 is a modular operating system for 386-based computers that supports multitasking, multiple users, and remote terminals and provides total security. It mimics some features available in minicomputer environments and, like most multiuser systems, requires a system administrator for providing overall support and maintenance and setting up and deleting user names. PC-MOS also is available for use on 8088 and 80286-based computers, but requires add-in, memory-management hardware to use other than conventional memory.

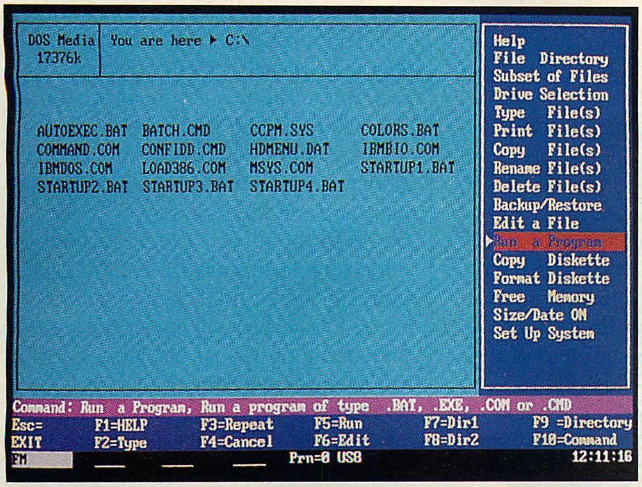
Setup. PC-MOS/386 is shipped on two 360KB diskettes. Setup instructions are clear, easy to find, and detailed; a one-page READ.ME file is provided with version 1.02. A complete reference manual, including a helpful glossary and index, describes MOS commands and functions, multitasking and multiuser concepts, file and directory organization, and system security.

Unlike Concurrent documentation that frequently refers to DOS, PC-MOS documentation mentions it rarely. The Software Link correctly assumes that users are installing the operating system on a newly delivered computer and begins by describing how to partition and format the hard disk. PC-MOS/386 uses a DOS-compatible disk-partitioning scheme; hard disks formatted under either system are accessible by the other. After installation, users are guided through the more complex creation of a CONFIG.SYS file, including a description of device drivers used by the system.

Using PC-MOS/386. Like Concurrent DOS 386, PC-MOS/386 has a faster set of video display routines, allowing applications that use DOS functions for text output to run quickly. The command-line environment closely resembles DOS with the addition of command-line editing and a recall buffer for convenience; system commands generally match DOS commands with a few exceptions and enhancements.

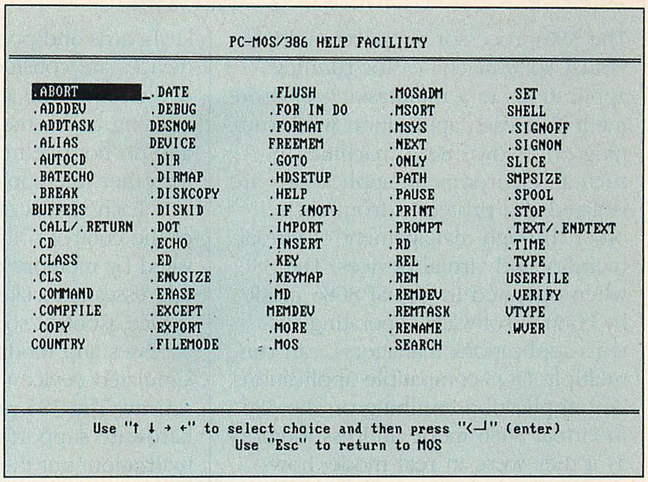
System commands can have an optional period prefix added to them, which informs PC-MOS/386 that the command is an operating system inter-

PHOTO 1: *Concurrent File Manager*



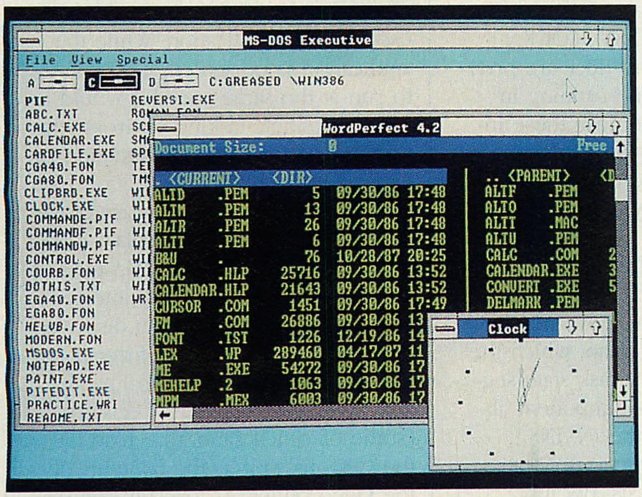
The file manager provides a menu-driven method for obtaining system services. Commands can be selected with the cursor keys or by entering initial command letters.

PHOTO 2: *PC-MOS/386 Help Screen*



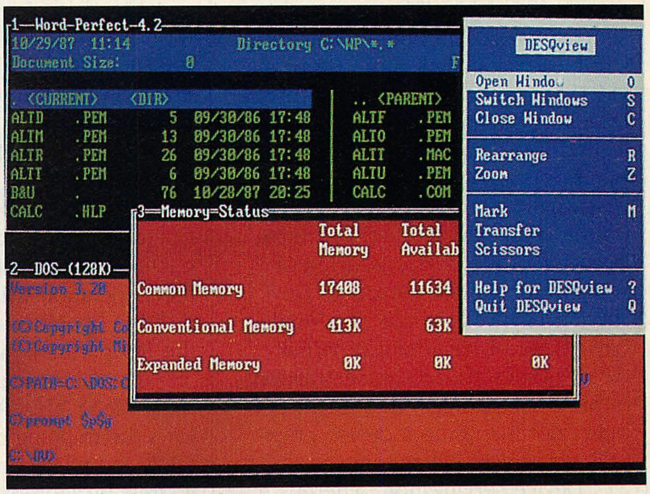
The on-line help facility is invoked by entering HELP at the command prompt. The user can then request the display of a comprehensive description of any of the items listed.

PHOTO 3: *Windows/386 Display*



Windows/386 uses all EGA video modes without difficulty and without being given extensive information; all windows are mapped to EGA graphics mode and displayed.

PHOTO 4: *DESQview Windows*



An application can have its own color scheme or use the default supplied by DESQview, which attempts to assign windows distinctive, easy to identify color schemes.

nal command rather than the name of a program file. This feature permits system customization by allowing programs to have the same name as operating system commands. For example, the command DIR will run a batch file or program named DIR if one is present, while .DIR always runs the internal command DIR. Because the need for this is limited (a system in which DIR and .DIR perform two different operations is generally undesirable), users can generally ignore optional period prefix instructions.

PC-MOS/386 provides full system administration and security features, including file-by-file directory access and partition (task) access security. Each file, directory, or partition can be assigned to 1 of 26 security classes identified by letters *A* through *Z*. Each user is assigned a security file defining that person's rights (no access, execute access, read or execute access, or complete access) to each security class. Security classes for newly created tasks or files can be defined explicitly or set to the creator's default access class.

Like Concurrent, PC-MOS/386 provides an on-line help facility. Entering HELP at the command prompt displays a menu of system commands (see photo 2). Users are presented with a comprehensive description of the items they select. The MOS system utility command also displays a screen describing its options if the command is invoked with no operands.

PC-MOS/386 starts only one session when the system is booted; new sessions can be started using the ADDTASK command. See table 3 for a list of PC-MOS/386-specific commands. Each task, assigned an ID number at start-up, begins on the main console or at remote terminals for which drivers have been defined in the CONFIG.SYS file. Each session runs in a virtual machine with an amount of memory specified by ADDTASK. Memory size of a task can range from 32 to 580KB, on systems using a VGA or an EGA, and to 644KB on systems using a CGA. Maximum task size is directly decreased by the amount of memory set aside for task supervision and device drivers; several tasks in excess of 550KB gener-

VIRTUAL MACHINES ON THE 80386

The 386 processor supports multiple virtual 8086 machines for running applications in a multitasking environment as if each application were running on its own 8086 machine. In such an environment, applications are isolated and protected from each other through management of virtual memory and virtual devices. The 386, when operated in virtual 8086 mode by control software (operating systems/applications managers), can run multiple DOS-compatible applications.

Applications running on the 386 in virtual 8086 mode address memory as if they were in real mode; however, addresses are translated into physical addresses using the 386's memory paging mechanism. This facility allows the 1MB address space of each virtual 8086 task to be mapped to a different portion of the physical memory available. Where a precise simulation of DOS operation is desired, each application can be provided with its own RAM image of the operating system as it would expect to find it on a single-tasking PC.

Control software supervises access to all system devices. Depending on the characteristics and operating behavior of the device, sharing or serialization can be provided. Device sharing involves the use of a single device and management of virtual devices (software-created simulations of hardware devices) that might or might not map onto a device physically present in the system.

Device serialization, whereby a device is dedicated as long as required—first to one task and then another, is usually employed with sequential access devices such as tape drives, printers, and serial ports.

Shared use of a single device is by far simpler and more common than serialization; it is an approach well suited to hardware, including keyboards and pointing devices. Such devices are considered to be wholly dedicated to the application currently running under the control software and do not need to provide services for other idle applications.

Each virtual device is a portion of the control software's code activated by memory or I/O accesses to addresses associated with the physical device. Control software traps those accesses and modifies the state of the simulated device to reflect the new activity. The 386 provides complete hardware support for such device virtualization, but the software required to implement it can be the most expensive and difficult part, because all the hardware quirks must be adequately duplicated by the software.

The 386 supports device virtualization using its privileged instruction and I/O permission map features. The 8086 instructions CLI, STI, LOCK, PUSHF, POPF, INT, and IRET are privileged on the 386 while running in virtual 8086 mode. Because these instructions can modify flags affecting the global state of the processor, they are always trapped by the processor. Control software can allow them to continue as normal, but more likely their operation will be simulated.

I/O operations are governed by the I/O permission bitmap, which the 386 maintains for each task state segment (TSS). This TSS component allows the trapping of the IN, INS, OUT, and OUTS instructions on an address-by-address basis. Because hardware devices are usually controlled by I/O accesses, the trapping of I/O reads and writes provides control software with information needed to determine the proper behavior of the simulated device. Because each task has its own bitmap, it is possible for different virtual machines to have different devices simulated.

The most powerful and visible device to virtualize is the display. Each application can write to what it believes to be the dedicated display adapter while the control software mediates access between virtual devices and the physical display itself. Access to the display can be toggled among the virtual displays, each of which is shown full screen when selected by the user, or it can be shared among virtual displays in a windowing environment.

Although the windowing environment displays all applications at the same time, it suffers because each application works in a virtual display at all times and experiences the performance degradation associated with such virtualization. The toggled display can, when an application is brought to the screen, substitute the physical device for the virtual device used by that application. While the application is on-screen, it continues to run at the same speed it would in a normal single-tasking environment. Because performance degradation is experienced only by applications not visible, users are not so aware of the slowness of the virtual display.

Devices such as the EGA present an extremely complex and interrelated set of interfaces. Data displayed depend on the contents of the Color Compare, Read Mode, Map Enable, and other EGA hardware registers (some of which cannot be read by the CPU) as well as the contents of the video buffer. As a result, software simulation of an EGA is a complex process that must be shifted into a new state at every control register access. As in virtual memory support, powerful device virtualization is a difficult and expensive task and should be looked for as a hallmark of sophisticated 386 control programs.

—Ed McNierney

ally can execute without difficulty. Tasks can spawn additional tasks by using the EXEC function call to initiate the ADDTASK system utility.

The user can switch task displays by depressing the Alt key and typing on the numeric keypad the desired task's ID number. Because this keystroke sequence is also used to enter IBM Extended ASCII characters from the keyboard, it can be toggled on and off with the Alt-999 sequence.

Users at any terminal can use ADDTASK to create tasks and can assign tasks an ID number and a batch file to execute. Each user in a multiuser system has access to the full capability of the system at his/her terminal. The REMTASK command terminates a task to which the user currently has exclusive access. Because users can attach to and view other tasks (subject to security limitations), a task cannot be removed if another user is viewing it.

The time slice allocated by default to each task is approximately 1/18 of a second. This can be changed by using the SLICE command in CONFIG.SYS during system initialization or by dynamically using the MOS system administrator command (MOSADM).

Device drivers for disk caching, RAM disk, emulation of the Lotus/Intel/Microsoft expanded memory specification (LIM EMS) using 386 page tables, and batch-file language are a few of the

TABLE 3: *PC-MOS/386 Specific Commands*

COMMAND	PURPOSE
ABORT	Stops processing within a batch file
ADDDEV	Dynamically adds a device driver
ADDTASK	Dynamically creates a memory partition for a task
ALIAS	Substitutes a drive letter for a directory name
AUTOCD	Restores drive and directory previously redirected
BATECHO	Controls the initial state of ECHO
CLASS	Assigns or changes a directory's security class
COMPFILE	Compares the contents of two files
DESNOW	Drives color display without snow pattern
DIRMAP	Displays disk directory map
DISKID	Assigns a volume identifier to a disk or diskette
ED	Creates and modifies text files
ENVSIZE	Specifies minimum environment space size
EXCEPT	Allows files to be excluded from a command
EXPORT	Creates a compressed backup copy of files
FILEMODE	Changes read-only or archive attributes of a file
FLUSH	Clears command recall buffer
FREEMEN	Defines regions above B0000H that MOS may use
HDSETUP	Sets up and maintains hard disks
HELP	Displays information about MOS commands
IMPORT	Restores compressed backup files
INSERT	Specifies insert mode for command line editing
KEY	Prompts for a keystroke
MOS	Controls memory, display, and I/O configuration
MOSADM	Controls system scheduling and disk caching
MSORT	Sorts records in a file
MSYS	Writes a boot sector to a disk
ONLY	Limits the action of a command to specific files
REL	Displays the release of MOS in use
REMDEV	Dynamically removes a device driver
REMTASK	Dynamically removes a memory partition
SEARCH	Searches one or more files for a character string
SIGNOFF	Exits a secured mode of MOS
SIGNON	Allows access to secured items
SLICE	Sets number of time slices for each partition
SMPSIZE	Sets size of system memory pool
SPOOL	Specifies where print files are to be sent
STOP	Causes an immediate exit from a batch file
TEXT	Displays a video screen from a batch file
USERFILE	Specifies the location of the system security file
VERIFY	Detects and fixes file allocation table errors
WVER	Specifies that disk writes are to be verified

PC-MOS/386 provides commands for configuring the system for multitasking, resource allocation, and system security. EXCEPT and ONLY are two examples of useful commands in PC-MOS/386 that limit the action of other commands.

DOS 3.3 features that are enhanced with PC-MOS/386. Additional batch-file language features include a full-featured text-output system supporting text colors and attributes, user prompting and input, command buffer manipulation, and task control commands.

PC-MOS's PIPE device driver, which defines character devices for transferring information between tasks, is quite useful. An eight-character device name and, optionally, a buffer size defines the pipe. Any number of pipes can be defined subject to available memory. Tasks write to pipes as they do to other devices; data are retained in the buffer until read by another task.

Drivers for auxiliary tools such as pointing devices can be specified in the system CONFIG.SYS file. DEVICE statements for drivers using ports and interrupts (otherwise used by the system's serial device driver) must be placed after DEVICE = $SERIAL.SYS.

PC-MOS/386 allows device drivers to be installed and removed at runtime instead of only at boot time, as is true in DOS. Reserved memory, called the System Memory Pool (SMP), is shared by all tasks and contains system resources and device-driver code. As long as space is available in the SMP, new device drivers can be added by any task and become available to all tasks. The SMP size defaults to 64KB, and the amount of memory remaining is reported each time that a new task is added to the system. For environments requiring many device drivers, the SMPSIZE statement in the CONFIG.SYS file allows the SMP to be set to any size up to a configuration-dependent maximum of 440KB.

Because remote terminals are supported through device drivers (drivers for 11 different terminal types are provided), the ability to add and remove drivers without rebooting is invaluable. In addition to standard communications support for remote terminals, terminal drivers provide alternative keystroke sequences so that PC-specific keystrokes (such as F1 through F10) can be generated at terminals that use incompatible keyboards.

Compatibility and performance. No difficulties in graphics or text modes were encountered by running DOS applications under PC-MOS/386. Graphics applications are supported in either CGA or EGA modes at the main console, assuming that the appropriate display adapter is installed; they are supported in CGA mode at remote terminals, such as remote PCs running terminal emulation software. Lotus 1-2-3 release 2.0 could be installed, removed, and run from a key disk even on a 386 running at 16 MHz—a great improvement over DRI's Concurrent DOS 386.

All software tested (the same products tested under Concurrent) ran smoothly. Because PC-MOS/386 is not a windowing system and allows only one task to be visible at a time, its job of display maintenance is relatively uncomplicated. Display modes are properly switched when moving from one task to another.

PC-MOS/386 utilities are a superset of DOS commands: system-monitoring and disk analysis utilities appropriate to the multiuser design of the system. A simple editor, called .ED, runs either as a line editor or in full-screen mode. The debugger, called .DEBUG, is compatible with Microsoft's SYMDEB debugger and has the ability to redirect the debugging session to any console on the system, allowing both applica-

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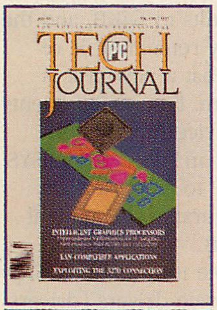

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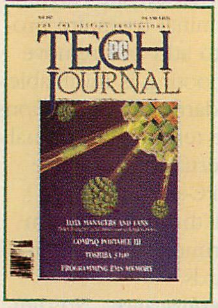

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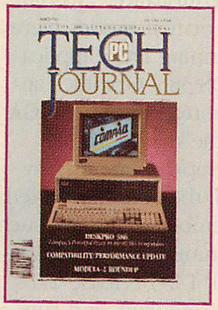

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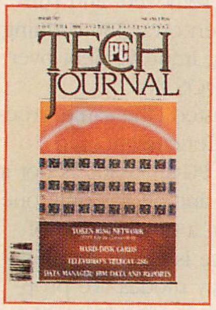

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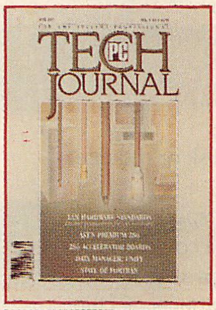

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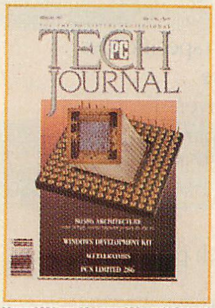

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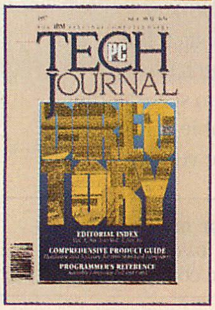

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tion output and debugging to be visible to users simultaneously. Although .DEBUG displays the processor type as 386 and the operating system as a whole requires the 386, the debugger surprisingly does not support 386 instructions or registers.

One of PC-MOS/386's clever features is its use of the 386 to provide complete emulation of IBM's NETBIOS network protocol. The system can treat each task as a physically distinct computer connected to a NETBIOS-compatible network. Applications running in different tasks can share data files and communicate using NETBIOS's peer-to-peer communications.

For software developers who want to provide network support for applications but cannot afford a whole network setup, this feature can be valuable. Network applications can be developed and tested, using a single computer. This is one example of how The Software Link is developing virtual-device support to take advantage of the 386's special hardware features.

Unlike OS/2, PC-MOS/386 provides support for full 32-bit native mode. This feature, along with planned support for MetaWare High C and Professional Pascal 32-bit compilers, will enable the efficient development and operation of very large applications on 386-based computers.

Multiuser asset. PC-MOS/386 is an excellent choice for small office situations that do not require the power of a minicomputer or a PC network. It is available in single-user, 5-user, and 25-user configurations. With a system administrator to set user and security partitions, the system provides users with a comfortable DOS-compatible environment. For single users, PC-MOS/386 offers a simple but fairly robust multitasking environment to support software development, background communications, or heavy applications use.

VIRTUAL ENVIRONMENT

Announced in September 1987, Microsoft Windows/386 is the newest product reviewed in this article and comes closest to exploiting 386 hardware capabilities fully. It provides a 386 virtual machine facility controlled by a Windows 2.0 user interface.

Getting started. The product is distributed on three 1.2MB diskettes and installed using Microsoft Windows' usual multiple-choice installation program. The copy of Windows/386 used for this review is the version distributed with, and for use on, Compaq Portable 386 and Deskpro 386/20 computers. Microsoft says its generic version will support a number of 386-based computers, including the IBM PS/2 Model 80.

Documentation is nicely illustrated and is a marked improvement over previous Windows documentation. It provides voluminous explanations on how to use the product, but little information on how it works; a seven-page READ.ME file comes with version 2.01. The user's guide describes Windows Desktop Applications, Windows Paint, and Windows Write, while a smaller booklet covers Windows/386.

Using Windows/386. Started from the DOS command line, Windows/386 creates a single virtual DOS machine in which Windows 2.0 is run. Windows applications selected from the DOS Executive menu run as they do in a standard Windows session. To run non-Windows applications, however, the 386 control software intervenes. If a Program Information File (.PIF) is available for an application, Windows/386 consults it for information (such as memory requirements and screen usage) about the virtual machine environment in which it should run. If no .PIF is available, Windows/386 makes assumptions about the application's hardware and memory requirements.

One of PC-MOS/386's clever features is its use of the 386 to provide complete emulation of IBM's NETBIOS network protocol.

It then creates a new virtual DOS machine in which it loads the application; the environment resembles Windows 1.0's support of non-Windows software. Depending on the program's .PIF file, the application might begin in a small window or run full screen. The Alt-Enter keystroke switches from full screen to a small window on the Windows 2.0 display surface while the application continues to run. Any number of non-Windows applications can be run in virtual DOS machine windows and are limited only by the amount of available memory because swapping is not supported (Microsoft recommends at least 2MB of extended memory).

Compatibility and performance. Windows/386 provides excellent display adapter virtualization. It is the only product described in this article that displays text mode, CGA graphics, and EGA graphics applications in windows while all applications are running and actively updating the screen. Adequate EGA virtualization is difficult and certainly the most notable technical achievement of Windows/386.

The product's value, however, lies more in ease of use than technical impressiveness. A user running Windows/386 with an EGA and enhanced color display can use all text and graphics applications without difficulty and without having to provide Windows/386 with extensive information; all windows are automatically mapped to EGA graphics mode and displayed (see photo 3). All application software tested, including EGA, CGA, and text programs (such as Lotus 1-2-3 at 16 MHz), run without problems.

The .PIF file editor provides information needed by Windows/386 to run non-Windows applications. Information required includes program name, minimum and desired memory requirements, and whether graphics support is needed. Desired amount of memory, if available, is allocated to the virtual DOS machine created for the application; if minimum memory is not available, the application cannot be run and Windows/386 displays an error box.

Settings in an application's .PIF also determine whether it starts in full screen or in a window, continues running when not in the foreground, and if other applications are suspended when it is in the foreground.

Windows/386 allows applications requiring a lot of processor resources to use Exclusive mode, in which the foreground application (running either full screen or in a window receiving keyboard input) is given total CPU time so that multitasking is temporarily suspended. For applications requiring little processor time except when used interactively, Windows/386 can set them to suspend automatically when in background. Text editors, for example, can be moved out of Windows/386's time-slicing schedule while in background, freeing more time for other tasks.

Windows/386 provides complete Windows clipboard support for applications, allowing both text and graphics data to be cut and pasted between non-Windows and Windows programs. In addition, an application's execution environment can be changed on the fly through the **Settings . . .** option, which is added to the System menu of non-Windows applications. **Settings . . .** dialogue also allows users to terminate a

non-Windows application, destroying the virtual DOS machine in which it runs. This feature allows users to clean out the system if software goes astray or hangs up; it first warns users that abnormally terminating a virtual machine can corrupt the system.

Virtual DOS machines supported by Windows/386 are normally isolated from each other. Pop-up programs, such as SideKick, and mouse drivers, such as Microsoft's MOUSE.COM, can be installed in them. When a mouse lies in an application's window, uncertainty could exist about whether it belongs to the application or to Windows/386. However, Windows/386 resolves the issue by giving the mouse only to applications running full-screen. This limitation is minor because display adapter simulation for moving the application's mouse pointer in a window would destroy interactive user mouse control. The DOS SHARE utility lets concurrently executing applications to share and lock disk files; it must run before loading Windows/386.

Windows/386 emulates expanded memory, using the system's extended memory; other expanded memory managers are not allowed. LIM EMS version 4.0 features are provided. Amount of memory available for expanded memory is set using the **emmsize** parameter in the WIN.INI file. If **emmsize** is not set, all available extended memory can be used as expanded memory. One problem with this setup is that an application requesting all available expanded memory could consume the extended memory needed to run other applications.

Windows/386 has a disk-caching program called SMARTDrive, for general system use as well as use with Windows/386. When used with Windows/386, it must be used with extended memory only. If configured in expanded memory, SMARTDrive's internal expanded memory manager conflicts with Windows/386's manager.

Limitations of Windows/386 are most noticeable when running multiple EGA graphics programs, each attempting to program its own 16-color palette. Windows/386 gives each full-screen application the palette it desires. For multiple applications displayed in windows sharing the same screen, it attempts to map color schemes using the EGA display driver's palette. For text-mode applications running in a window, Windows/386 tracks the cursor position so that prompts for user input are always displayed, even if most of the application's display is hidden.

Device virtualization does not come for free, and Windows/386 gives the user control over the balance between multitasking and individual application performance. EGA applications run in windows up to 50 times slower than in full screen; high-speed communications programs might require exclusive use of the CPU to avoid loss of incoming data. Windows/386 can give the entire EGA display to applications running full screen, allowing them to run almost as quickly as they could outside Windows/386. With the Alt-Tab key, users can switch from one full-screen application to another without loss in performance.

Windows/386's virtual machines, though well isolated, bump into each other when they contend for physical devices such as serial and parallel ports. If two non-Windows applications attempt to use the same port, Windows/386 displays a dialogue box explaining the difficulty and asks the user to identify the one to have access to the port. A simulated hardware error is returned to the unselected application to indicate that the device is not present. The user must then terminate that application and retry access only after the first application terminates ownership of the port. This contention is inevitable because standard DOS applications are not designed to share communications hardware.

Windows/386's virtual machines, though well isolated, bump into each other when they contend for physical devices such as ports.

Impressive environment. Microsoft Windows/386 provides a technically impressive and powerful multitasking environment and comes closest among the products reviewed to providing a true virtual machine environment. Windows/386 supports existing Windows applications and non-Windows applications cooperatively. Non-Windows applications can be toggled into the foreground to run full screen without the Windows user interface.

Additionally, users can migrate from running multiple DOS applications under Windows/386 to running multiple OS/2 applications under the OS/2 Presentation Manager with no change in user interface, perhaps easing the learning transition to OS/2.

MULTITASKING PLATFORM

DESQview from Quarterdeck Office Systems has been available since 1985 as a multitasking environment for 8086-based PCs. Running with Quarterdeck's 386 expanded memory manager (QEMM 386) or Compaq's expanded memory manager (CEMM), DESQview 2.01 provides a multitasking virtual machine platform for 386-based computers. DESQview provides complete scheduling and interprocess communications features.

Simple start-up. DESQview's installation process is simple and convenient. Because DESQview requires an information file (.DVP) for each application it runs, the installation program searches the hard disk on which DESQview is being installed for familiar applications. DESQview's thorough search even discriminates among various versions of a particular product.

QEMM 386 also installs easily; an installation program automates the process, even though users need only copy the device-driver file QEMM.SYS and modify CONFIG.SYS to include it.

DESQview's documentation is generally good and professional. In tutorial format, it describes how to create .DVP files, start applications, use DESQview's cut-and-paste facilities to transfer text between windows, and use DESQview's LEARN feature to create keyboard macros. It also briefly describes DESQview's application interface for software developers who wish to create DESQview-specific applications. The 30-page appendix on expanded memory usage in standard and 386 systems is perhaps the best available description of that subject. Customer support services and warranties are clearly spelled out.

Using DESQview. Users can start DESQview at any point in a DOS session. A start-up screen is displayed, followed by a window and applications program selection menu. DESQview supports a mouse for menu selection and window manipulation, although cursor key and keyboard mnemonic commands are also provided. As users become familiar with DESQview, they most likely will find that a combination of keyboard menu selections and mouse-based window control provides the easiest operating environment. The use of a mouse is highly recommended.

For newly opened applications, DESQview uses the information—including the application's memory

"How to protect your software by letting people copy it."

By Dick Erett, President of Software Security

Inventor and entrepreneur, Dick Erett, explains his company's view on the protection of intellectual property.

"A crucial point that even sophisticated software development companies and the trade press seem to be missing or ignoring is this:

Software protection must be understood to be a distinctively different concept from that commonly referred to as copy protection.

Fundamentally, software protection involves devising a method that prevents unauthorized use of a program, without restricting a legitimate user from making any number of additional copies or preventing program operation via hard disk or LANs.

Logic dictates that magnetic media can no more protect itself from misuse than a padlock can lock itself.

Software protection must reside outside the actual storage media. The technique can then be made as tamper proof as deemed necessary. If one is clever enough, patent law can be brought to bear on the method.

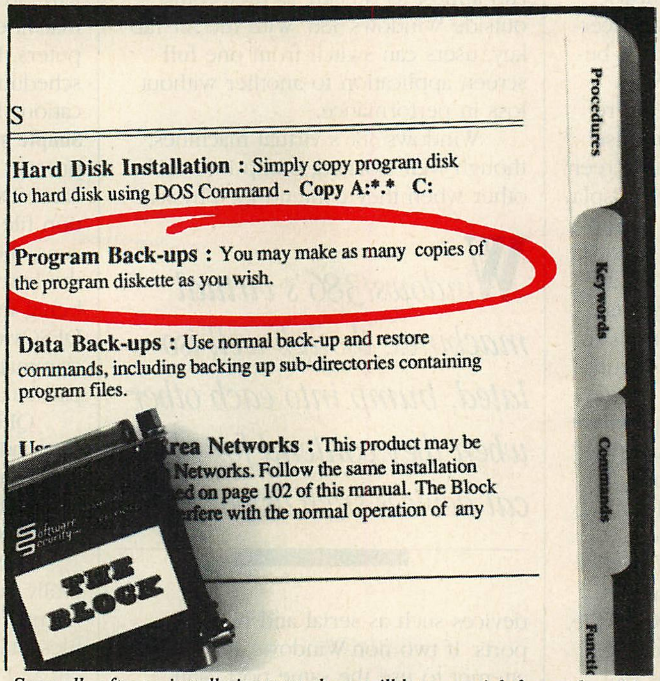
Software protection is at a crossroads and the choices are clear. You can give product away to a segment of the market, or take a stand against the theft of your intellectual property.

"...giving your software away is fine..."

We strongly believe that giving your software away is fine, if you make the decision to do so. However, if the public's sense of ethics is determining company policy, then you are no longer in control.

We have patented a device that protects your software while allowing unlimited archival copies and uninhibited use of hard disks and LANs. The name of this product is The BLOCK™.

The BLOCK is the only patented method we know of to protect your investment. It answers all the complaints of reasonable people concerning software protection.



Soon all software installation procedures will be as straightforward as this. The only difference will be whether you include the option to steal your product or not.

In reality, the only people who could object are those who would like the option of stealing your company's product.

"...eliminating the rationale for copy-busting..."

Since The BLOCK allows a user to make unlimited archival copies the rationale for copy-busting programs is eliminated.

The BLOCK is fully protected by federal patent law rather than the less effective copyright statutes. The law clearly prohibits the production of work-alike devices to replace The BLOCK.

The BLOCK attaches to any communications port of virtually any microcomputer. It comes with a unique customer product number programmed into the circuit.

The BLOCK is transparent to any device attached to the port. Once it is in place users are essentially unaware of its presence. The BLOCK may be daisy-chained to provide security for more than one software package.

Each software developer devises their own procedure for accessing The BLOCK to confirm a legitimate user. If it is not present, then the program can take appropriate action.

"...possibilities... limited only by your imagination..."

The elegance of The BLOCK lies in its simplicity. Once you understand the principle of The BLOCK, hundreds of possibilities will manifest themselves, limited only by your imagination.

Your efforts, investments and intellectual property belong to you, and you have an obligation to protect them. Let us help you safeguard what's rightfully yours. Call today for our brochure, or a demo unit."

Software Security inc.

870 High Ridge Road Stamford, Connecticut 06905

203 329 8870

requirements, start-up files, and default directory—that is provided in the .DVP file. The information gives DESQview better control over the application's use of PC hardware.

Applications can have their own color scheme or use the default supplied by DESQview, which attempts to assign distinctive color schemes to windows that will readily distinguish them on the screen (see photo 4). Customized color for applications is a welcome relief to DESQview's default color schemes, which are often garish and hard to read.

Text-mode applications, by default, run in small windows. If a program switches to graphics mode, the window is zoomed to full screen and can later return to a small window. CGA (but not EGA) graphics applications can continue running automatically in small windows, but DESQview's documentation on how to accomplish this is unclear. It states only that the number of text pages of a CGA application running in a small window must be set to 4. Users set the number by using the Advanced Options screen in DESQview's Change-a-Program utility. The number of text pages used is specified on that screen along with information about interrupt vectors used, keyboard incompatibility levels, and other features that will certainly challenge the novice user. Although it is reasonable for DESQview to require users to identify applications using graphics, an easier mechanism is needed.

Compatibility and performance. Lotus 1-2-3 release 2.0 could not be installed at 16 MHz using DESQview. Therefore, Lotus 1-2-3 must be installed on the hard disk before DESQview is loaded; DESQview can then be installed and Lotus 1-2-3 run in windows using a preloader provided by Quarterdeck. Multiple copies of 1-2-3 can be run (DESQview supports up to nine windows simultaneously) and properly share use of the 80287 math coprocessor for recalculations.

In general, DESQview runs all DOS applications tested when their .DVP files are set properly. EGA applications run when zoomed to full screen, but execution is suspended when switched back into a small window because DESQview currently does not virtualize EGA graphics operations.

The .DVP files provide considerable application control, and DESQview comes with a large set of default files. Because DESQview can swap programs from memory to expanded memory or to disk, control features are provided to disable swapping for realtime applications (such as communications programs that might lose input characters if swapped out of memory when the characters arrive). A properly set .DVP file can give DESQview enough information to tailor an application's requirements to obtain optimum performance and compatibility.

QEMM 386, priced separately from DESQview, provides expanded memory for DESQview and other applications. Version 4.0 is an expanded-memory driver that simulates expanded memory using extended memory. The driver is compatible with LIM EMS 4.0.

DESQview provides a built-in application program interface (API) compatible with the IBM TopView 1.1 API. Programs written using DESQview's API manipulate windows and subwindows, spawn subtasks, and communicate with other programs and subtasks.

DESQview Companions 1, also separately priced, provides calculator, datebook, notepad, and communications utilities. The calculator and notepad operate on information obtained from windows using DESQview's Mark-and-Transfer feature.

DESQview can display graphics and text windows on the screen simultaneously. When the active window is in graphics mode and the user switches to a text-mode window, text is displayed in graphics mode. If a switch is made between incompatible video modes, DESQview covers the original window with a "graphics curtain" made of dither-pattern characters.

EGA version on the way. For character-based and CGA applications, DESQview provides a pleasing user environment and a convenient, compatible multitasking platform. Because the EGA is rapidly becoming the entry-level graphics device, support for windowed EGA graphics is planned for DESQview/386.

That version of DESQview also promises to support 32-bit protected-mode applications when used with Phar Lap Software's 386/DOS-Extender. This will allow applications that use the 386/DOS-Extender (such as Borland's Paradox 386) to run simultaneously with DOS applications.

For users reluctant to move to a totally unfamiliar operating system, DESQview offers an inexpensive, compatible solution with the ability to exploit the 32-bit capabilities of the 386.

MULTIPLE APPLICATIONS NOW

The four products reviewed here—Concurrent DOS 386, PC-MOS/386, Windows/386, and DESQview 2.01—admirably provide features not available under DOS. They do so in an environment that is familiar to DOS users (sometimes using helpful graphics interfaces), and they permit multitasking among applications. As with OS/2, internal multitasking within applications requires that the application be specifically designed to use interfaces provided by the product.

One advantage of OS/2 is that it runs on both 286- and 386-based machines, while some of these alternative products do not. Additionally, a large number of developers already have announced future products for the OS/2 multitasking environment, but their release is months away.

On the other hand, thousands of DOS applications, which users have invested heavily in, are available now. Unlike OS/2, Concurrent DOS 386, PC-MOS/386, Windows/386, and DESQview 2.01 can run multiple DOS applications at the same time. For users who need to run multiple applications *now* and who have the resources to purchase 386 hardware, these products provide a means of meeting that need without prematurely parting from DOS.

Digital Research, Inc.
60 Garden Court
P. O. Box DRI
Monterey, CA 93942
800/443-4200
Concurrent DOS 386: 3-user system, $395.00; 10-user system, $495.00
CIRCLE 345 ON READER SERVICE CARD

The Software Link
3577 Parkway Lane
Atlanta, GA 30092
404/448-5465
PC-MOS/386: 1-user multitasking, $195.00; 5-user multitasking, $595.00; 25-user multitasking, $995.00
CIRCLE 346 ON READER SERVICE CARD

Microsoft Corporation
16011 NE 36th Way
P. O. Box 97017
Redmond, WA 98073-9717
800/426-9400; 206/882-8080
Windows/386: $195.00
CIRCLE 347 ON READER SERVICE CARD

Quarterdeck Office Systems
150 Pico Boulevard
Santa Monica, CA 90405
213/392-9851
DESQview 2.01: $129.95
CIRCLE 348 ON READER SERVICE CARD

Ed McNierney is the principal engineer for Lotus Development Corporation.

PC BRAND™ SPEAKS YOUR LANGUAGE

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Compile dBASE for Speed, Protection

Clipper™ turns lumbering dBASE® into a speed dMON with benefits bobbing in its wake: your source code is submerged from public view, you can distribute your compiled application without royalties, and your customers don't even need copies of dBASE! The Spring '87 Clipper offers index files compatible with dBase III Plus, and networking capabilities to run compiled programs on major networks supporting DOS 3.1 with no restrictions on number of users. Clipper offers arrays, menu-building commands, user-defined functions, context-sensitive help techniques for applications, a debugger, and it supports Expanded Memory. It goes well beyond dBASE with 1,024 fields per data base and 2,048 active memory variables.

Clipper has the power to save and restore multiple screens to and from memory variables. You can also create overlays, call object modules compiled in other languages, and create function libraries to link with your applications. Power and flexibility make it the #1 dBASE compiler. List: **$695**, PC Brand: **$375**.

McMAX *From Nantucket*

Like dBASE for the Macintosh

McMax™ is like running dBASE on the Macintosh. It combines an easy-to-use menu-driven ASSIST mode using the Mac interface, an interactive command mode like dBASE at the dot prompt, and an application programming language fully compatible with dBase III. It gives you the power to create dBASE language applications on the Macintosh and transfer back and forth to the IBM® world. McMax accommodates up to 16 million records, 32,000 characters per record, 255 characters per field, and up to 32 files open concurrently. No copy protection. List: **$295**, PC Brand: **Call**.

dBASE AT THE SPEED OF C

dBx Translates dBASE Applications to C

You dBASE™ programmers know what an expressive and readable language dBASE is. It's a very comfortable development environment. But the price is debased performance. Even compiled dBASE doesn't offer the speed that some users require these days. The kind of speed offered by software written in the C language. The answer is dBx™.

dBx translates dBASE to C. It offers you a major competitive advantage over the next dBASE programmer: Keep writing in dBASE. Take every application all the way to completion. Then use dBx to translate them top to bottom to C!

Other advantages: C is portable, even to other operating systems like UNIX/Xenix™. To the Macintosh or Amiga. dBx gives your applications a passport to places dBASE cannot go.

Has its own file manager for single user, but links to major C file managers—c-tree and dBC—for compatibility with dBASE files or multi-user support. We have everything you'll need, including good advice.

	List:	PC Brand:
dBx	**$ 350**	**$ 299**
with Library Source	**$ 550**	**$ 469**
with Full Source Code	**$1500**	**$1282**

dBC *Identical dBASE III Plus Files Using C*

dBC™ is a series of C libraries from Lattice which creates, accesses and updates files identical to those of dBASE itself. So dBASE can read and update the files too.

What for? It means both C and dBASE applications can operate on the same data bases interchangably. It means C programmers can interface with the big market of dBASE users out there, yet side-step the dBASE language. It means dBASE applications can now be linked to the universe of C libraries and tools to add windows, graphics, statistical analysis, all the things dBASE cannot do. It means the speed and power of C to impress clients accustomed to dBASE!

dBC's functions parallel all dBASE's file handling commands, many decomposed to permit direct data manipulation. Our versions of dBC mimic file formats for dBASE II and III and now dBASE III Plus makes your programs network ready!... as many stations as a network allows. Hands-off mode handles record and file locking and unlocking automatically. Close in functions give you direct lock/unlock control.

Supports all four memory models. dBASE II, III...List: **$250**, Ours: **$195**. dBASE III Plus...List: **$750**, Ours: **$595**. *Pay double and you get source too!*

SUPER SOURCE

Aldebaran's Source Print

Author Alan Simpson writes "the best overall debugging technique is to draw lines to connect all the IF and DO WHILEs etc. with their ENDIFs and ENDDOs. Then use a pencil to"—Well, thanks, Alan, but we'll use Source Print instead. It draws those vertical lines to connect the beginnings and endings of structure in a vivid display of your program's organization. It can print your programs with page numbers, headings, line numbers, indent automatically, throw in a table of contents and cross-reference index. "Occasionally a utility comes along that makes a programmer's life much easier. Source Print is such a program" says *PC Magazine*. List: **$97, Ours: $75.**

...add Tree Diagrammer

Tree Diagrammer prints an organization chart of your program's structure showing the hierarchy of function, procedure, and subroutine calls. Shows at a glance what routines call each other for clearer debugging. Every shop should have this important documentation tool. List: **$77**, Ours: **$67.**

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We refund the purchase price of any product returned within 30 days in entirely resalable condition. ***You can even try out many programs themselves.*** *Ask your salesperson for details. There's just nothing stopping your buying from PC Brand.*

C-WORTHY INTERFACE LIBRARY *NEW VERSION!*

The C-Worthy™ Interface Library wraps an entire user interface around your application. Its full power can be summoned by only a few high level calls. Sound exaggerated? A single function call can set up a complete text editor in a screen window. Recently acquired by Solution System, over 600 pages of Documentation, Turbo and Quick C version and a complete Interface Library have been added.

- High level calls pop menus and scrollable choice lists to the screen, restoring the background when dismissed.
- Windowing facilities open portholes of up to screen size for viewing virtual screens larger than the physical screen.
- Full context-sensitive help screen management takes over these chores and error messages. Automatic routines interrupt with pageable text windows explaining what to do next.

Novell found it "played a key role and accelerated development" in making its NetWare™ utilities easier for users. Ingenious demo: call for it.

Ask for:	List:	PC Brand:
C-Worthy	**$195**	**Call**
with Forms Library	**$295**	**Call**

BASTOC *BASIC Into C*

For a trifling price, BASTOC™ moves truckloads of BASIC code over to C. It's a translator which takes in Microsoft Extended BASIC and emits pure K&R C for Microsoft or Lattice. Structures even convoluted BASIC code. Optimized to dramatically reduce execution time. Dynamic string allocation ends BASIC's catatonic halts for garbage collection. Huge worksaver. List: **$495**, Us: **$399**.

BTRIEVE *B-tree File Manager Plus Add Ons*

If networks are on your horizon, betting your future on Btrieve as the one file manager for your C, Pascal, BASIC, and COBOL projects looks like a smart move. Reason? Novell bought Btrieve's creator.

Btrieve's function library takes complete charge of all file creation, indexing, reading, writing, insertion, deletion, space recapture, forward and backward searching. Finds any key in a million in four or less accesses. Files may have up to 24 indexes; fixed record length to 4090 characters; variable length to 64k; indexes up to 255 characters; files of 4 billion bytes.

List: **$245**, Us: **$195**. Network Version List: **$595**, Ours Only: **$465**. Ask about Xtrieve for Btrieve file inquiry, Rtrieve for report writing. For any network that supports the MS-DOS 3.1 file sharing function.

PANEL PLUS

Library Source Code Gives It Complete Portability

There are no end of tools for screen design and data entry, but none quite like Panel Plus. Design a screen under program control, use Panel's utility to "run" and test it field by field, then pass it to Panel's code generator which delivers C source code. Options style the code to your compiler's liking, and you can of course do what you like to the source afterward. The code calls Panel Plus's function library, but now *the library comes in source,* so everything produced is highly portable. Not like other screen managers delivered as object libraries and which leave *you* to write the detailed code.

Panel Plus will operate in graphics mode via interfaces to graphics products it supports and can utilize the EGA's 43-line screen. Low-level I/O functions adapt it to various keyboards, screens, operating systems.

Panel's newest incarnation has every imaginable feature. A single screen design can have 1000 fields stacked as visual overlays up to 127 levels deep or as pop-ups. Groups of fields can be moved between levels. Screens can be output as compilable code or stored on disk for loading at run-time. Each field can be boxed, colored, multi-row, word-wrapped, and scrolled horizontally and vertically if larger than its on-screen view aperture. It can be assigned its own help and error message, can be told to accept certain characters, or to match a picture, and to check data after entry—proper dates, number ranges, etc.—using Panel's or your own validation routines. You can add your routines to Panel's test utility because even it comes as source. Fields are accessed in any order and control reverts to your application program after each field for choice of action.

For past Panelists, the new version has smaller and faster field and screen functions, tighter granularity, and an enhanced, reworked library. Major tool for the serious developer. List: **$495**, PC Brand: **$395**.

POLYTRON VERSION CONTROL

Source Code Control for Any Language

PVCS allows programmers, project managers, librarians and system administrators to control the proliferation of revisions and versions of source code in software systems. Independent programmers, the leading software publishers and LAN companies, and hundreds of Fortune 1000 companies rely on PVCS to store and retrieve multiple revisions of text. It maintains a complete history of revisions as an "audit trail", generates status reports, and uses intelligent "difference detection" to minimize disk space for each new version.

On Corporate and Network PVCS simultaneous changes to a module are merged into a single new version. If changes conflict, the user is notified. The "Logfiles" used to track changes are interchangeable between any PVCS product.

Corporate PVCS is for multiple programmers. It includes "branching" to maintain code when programs evolve on multiple paths. Personal PVCS offers most of the power and flexibility of corporate PVCS, but excludes multiple programmer features. Network PVCS is the Corporate version for LANs. File locking and security levels can be tailored to each project.

PolyMake Still using a prehistoric Make? Step up to PolyMake, the most popular and powerful Make utility. Most flexible macros of any Make. Now integrated with PVCS and PolyLibrarian for faster performance and precise configuration management.

Ask for:	List	PC Brand:
Personal PVCS	**$149**	**$109**
Corporate PVCS	**$395**	**$309**
Network PVCS	**Call**	**Call**
PolyMake	**$149**	**$109**

Payment: We honor MasterCard, Visa, American Express (no surcharge), checks in advance, or funds wired to PC Brand, c/o Chemical Bank, 126 East 86 St., New York, Account 034-016058. COD (U.S. only) for cash, money order, certified check (no fee). NY State, add sales tax. Purchase orders accepted from larger corporations and institutions at our discretion if you agree to net 30 days plus 2% a month late penalty thereafter.

Shipping & Handling: U.S.: UPS Surface: 1st product $6, each add'l $3. UPS 2nd Day Air: 1st product $10, each add'l $4.50. UPS Next Day Air or Federal Express 1-2 Day Air: 1st product $18, each add'l $6. FedEx Next Day 10 AM: 1st product $28, each add'l $7. International: Charges vary by destination and carrier. $10 per shipping container for export forms. Air parcel post at your risk beyond collected insurable amount.

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With a name that belies its thoroughness, Brief™ has every feature you've ever contemplated for your editor-in-chief. Text in multiple buffers is scrolled through one or more windows you open, close, resize. A text buffer may be called to different windows to view two areas at once. A change in one changes both. Text blocks may be marked for printing, writing to files, movement to scrap buffers for cut and paste into other buffers, with as many "undo" levels as you want.

Brief has text search abilities rivaling "grep", with wildcards for matching and indifference to intervening characters.

If you use Lattice, C86™, or Wizard, and have 320k, you can compile your C program without ever leaving Brief. It finds the lines with errors, and marches you through the text for repairs.

Parts of Brief were written with its own easy-reading Lisp-like macro language which has structure, conditionals, loops. "Simply the best text editor you can buy", - Dvorak *Infoworld*. (Needs 192k.) List: **$195**, PC Brand: **Call.**

C-TREE & R-TREE

B-Tree File Manager Now Has Report Generator

c-tree: The only major b-tree file manager with network support in the standard low-cost version, c-tree™ gives you record-locking routines for DOS 3.1/3.2, UNIX and XENIX, and it even comes in C source code, yet there are no royalties. Source sticks to K&R, so C-tree is portable. Tests in many environments prove it.

Permits any number of keys for a data file—alpha, numeric, even floating point. Handles files with varied record lengths, multiple keys in one index file. Both high level and decomposed functions. It's the works.

r-tree: Adds the ability to produce ad hoc reports from files maintained by c-tree (v. 4.1 and up). Link a file description to the r-tree™ library, and use any text editor to write report scripts with no further C coding. Reports can access data in several files, select on criteria, join findings into new logical records, sort them, calculate new fields and columns, tabulate by control breaks. Comes in source, same portability as c-tree, and fits any compiler.

	List:	Ours:	Combined:
c-tree:	**$395**	**$329**	**$541**
r-tree:	**$295**	**$245**	

WINDOWS for DATA

FIRST PRIZE!

M'Soft Windows Compatible

"Only one package can be easily recommended" said *Computer Language* (June '87) reviewing nine window and data entry products for C. Complete field level functions specify prompt string, field length, data type, screen location, picture, target variable, entry rules, help messages, even functions to call for validation once data keyed in.

Windows for C is a subset. No data entry but all windowing functions. Unlimited windows can be made either to pop up or permanently overwrite the screen, scroll and highlight lists vertically and horizontally. Specify Compiler. Windows for Data: List **$295**, Ours **$259**. Windows for C: List **$195**, Here **$149**.

ESSENTIAL C UTILITY LIBRARY

400 Functions, 30c Each

You've probably seen the speed and power of Essential's C function library without knowing it. Software greats have been using it for some time to give today's top products pizazz and panache.

Now grown to 400 functions Essential produces pop-up menus, saves and restores screens and windows to disk or memory in as little as 1/10th second, and claims the fastest video output available. Library has 50 business graphics functions, 40 string handlers, 28 functions for printers, 18 for mice, 11 for time and date, DOS interface functions for disk error trapping, directory and file creation and management, lots more. Everything in source, including sample programs. We have versions with pre-built libraries for the well-known C compilers, and a source code librarian is supplied for rolling your own.

	List:	PC Brand:
C Utility Library	**$185**	**$119**
Essential Graphics	**$250**	**$183**
Essential Communications	**$185**	**$125**
with Breakout Debugger	**$250**	**$189**

Shopping List for the Power Workbench

ARITY PRODUCTS	LIST	US
Arity Combination Package	1095	979
Expert System Development Pkg	295	229
PROLOG Advanced Toolbox	150	119
PROLOG Compiler & Interpreter	650	569
Arity File or Screen Design Toolkits	50	44
SQL Development Package	295	229
Arity PROLOG Interpreter	295	229
Arity Standard Prolog	95	77
AI-EXPERT SYSTEMS		
EXSYS *Development Software by EXSYS*	395	309
EXSYS Runtime System	600	469
Insight 2+ *by Level Five Research*	485	379
AI-LISP LANGUAGE		
IQCLISP *by Integral Quality*	300	Call
IQLISP *by Integral Quality*	270	Call
Microsoft LISP *Common LISP*	250	199
TransLISP *from Solution Systems*	95	Call
TransLISP PLUS *from Solution Systems*	195	Call
AI-PROLOG LANGUAGE		
APT *Active Prolog Tutor from Solution Sys.*	65	Call
Prolog-86 *from Solution Systems*	125	Call
Prolog-86 Plus *from Solution Systems*	250	Call
Turbo PROLOG *by Borland Int'l*	100	63
Turbo PROLOG Toolbox *by Borland Int'l*	100	64
ASSEMBLERS & DEBUGGERS		
Advanced Trace-86 *Morgan Debugger*	175	119
C-Sprite Debugger *by Lattice, source level*	175	139
Microsoft Macro Assembler *with Utilities*	150	109
PASM86 *by Phoenix, Macro Assembler*	195	138
Periscope I Debugger...*The Periscope Co.*	345	289
Periscope II *with NMI Breakout Switch*	175	139
Periscope II-X *software only*	145	105
Periscope III *with Advanced Board...New*	Call	Call
BASIC LANGUAGE		
Microsoft BASIC Interpreter *for XENIX*	350	295
Microsoft QuickBASIC Compiler...*3.0*	99	79
BORLAND PRODUCTS		
Reflex & Reflex Workshop	200	129
Reflex *Data Base System*	150	89
Reflex Workshop	70	45
Turbo Basic...*New*	100	64
Turbo C Compiler...*New*	100	64
Turbo Lightning	100	64
Turbo Pascal & Tutor...*New*	125	85
Turbo Pascal with 8087 & BCD	100	64
Turbo PROLOG Compiler	100	63
Turbo PROLOG Toolbox	100	64
Turbo Tutor	40	28
C COMPILERS		
C86 PLUS *by Computer Innovations...New*	497	397
Lattice C Compiler *from Lattice*	500	299
Let's C Compiler *by Mark Williams*	75	55
with CSD Source Level Debugger	125	90
MWC-86: Mark Williams C Development	495	369
Microsoft C Compiler ...*4.0*	450	295
Turbo C Compiler *by Borland...New*	100	64
C INTERPRETERS		
C-Terp *by Gimpel Software*	300	249
Instant C *by Rational Systems*	500	395
Interactive-C *by IMPACC with debugging*	249	219
RUN/C Professional *from Lifeboat*	250	185
COMMUNICATIONS		
Asynch Manager *by Blaise, for C or Pascal*	175	135
Greenleaf Communications *by Greenleaf*	185	139
C UTILITY LIBRARIES		
Blaise C TOOLS PLUS/5.0	129	99
Blaise Turbo C TOOLS	129	99
Blaise C TOOLS PLUS	175	135
C Food Smorgasbord *by Lattice*	150	109

	LIST	US
C Utility Library *by Essential, 300 functions*	185	119
Greenleaf Functions *by Greenleaf Software*	185	139
COBOL LANGUAGE		
RM/COBOL...*see Ryan-McFarland Prod.*		
Microsoft COBOL Compiler	700	499
Microsoft COBOL Compiler *for XENIX*	995	795
Micro Focus COBOL...*see Micro Focus Prod.*		
dBASE SUPPORT		
BRIEF/dBRIEF...*Brief for DBASE III*	275	Call
CLIPPER...*from Nantucket*	695	375
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The CodeView™ debugger uses windows to show everything on one screen: source alongside disassembled object, variables, stack and registers. Drop down windows obviate learning of commands. "A source-level debugger that puts the rest to shame" said Dobb's.

Microsoft C has five memory models for code and data, plus non-library support for another thirteen, and boasts alternate math packages for speed versus accuracy, with or without 8087/80287 chips.

Both linker and library manager are part of the package, as is the "make", which knows how to rebuild any size project by compiling only elements which have changed.

It is reportedly used by Lotus, Ashton-Tate and, fittingly, Microsoft itself to develop Windows. Dobb's calls it "the best MS-DOS C development environment value today [for] virtually any kind of program conceivable." 320k suggested.
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The DOS-UNIX Union

Choosing between DOS and OS/2 would seem to be the operating system question at hand, but DOS Merge 286 puts the veteran UNIX back into the running.

WILLIAM TROPP and STEPHEN WRIGHT

Just because DOS and OS/2 have been getting all the attention of late does not mean that UNIX has surrendered. The UNIX community, too, has a stake in the operating system wars that are about to take off.

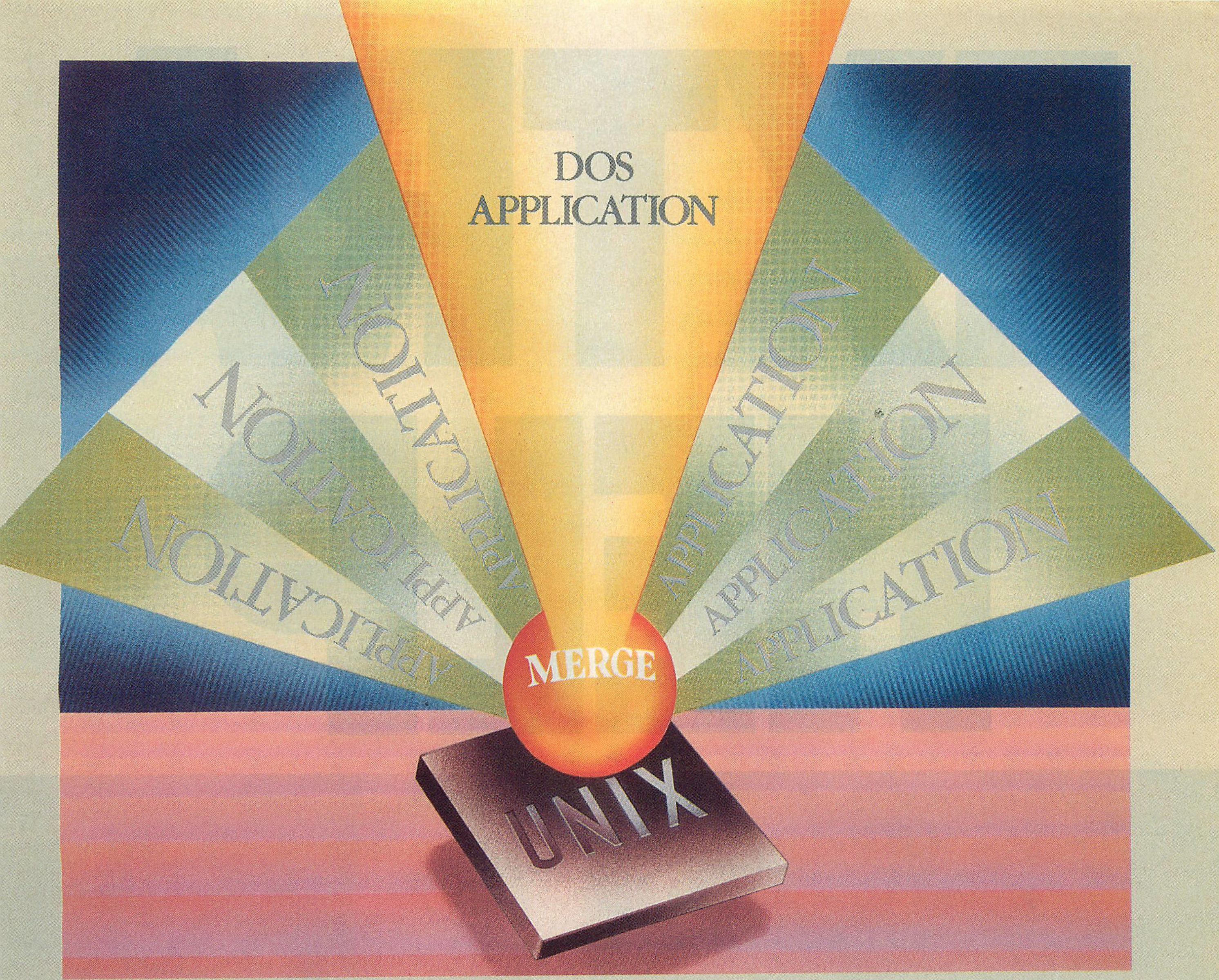
One weapon available to the UNIX forces is a product that combines DOS and UNIX features: DOS Merge 286 from Locus Computing Corporation is a dual operating system that allows users to boot up Microport's UNIX System V and execute native UNIX commands in the 80286 processor's protected mode, while executing Microsoft DOS (MS-DOS) applications in real mode as one of several concurrent UNIX tasks. Users can operate a DOS task on a PC/AT with UNIX tasks concurrently executing, using the same disk partition. No apparent speed degradation occurs when DOS is the only task run, but DOS screen I/O slows considerably when several UNIX tasks run.

Merge 286 is one of several options available to developers pondering the pros and cons of changing their systems to OS/2 (see "Choosing an Operating System," Ed McNierney, p. 50). Merge 286 appears to users as a single operating system under which DOS or UNIX applications run. Users need not know whether the application is to run under DOS or UNIX.

The product is especially appealing to two groups: those who have UNIX but would like to run or create DOS applications and those who are DOS-oriented but interested in exploring UNIX with its unrivaled wealth of programmer productivity tools (specialized editors, compiler generators, source code control systems, filters).

Merge 286 originated from a late-1970s UCLA research project, the intent of which was to permit full network access to unsophisticated users through a concept called network transparency. In 1983, Locus introduced PC-Interface, which allowed PCs to act as an intelligent terminal for UNIX and used a UNIX system as a print spooler and file server for DOS. In the following year, development of Merge 286 (which incorporates PC-Interface) began and, in 1985, AT&T shipped an early version called Simul-Task that worked only on the AT&T 6300+. Finally, in October 1987, Locus introduced Merge 286 with Microport's UNIX System V/AT, for use on most 80286 AT compatibles. To bring the history right to date, DOS Merge 386 was hot on the heels of its 286 sibling in November 1987, providing an environment that exploits the additional features of the 80386, such as multiple DOS applications.

UNIX alone can run with just 512KB base memory and UNIX plus Merge 286 with at least 1.5MB of memory, but both products require more for optimal performance. For a single user, Locus says that 2MB of extended memory provides the same performance as more memory would. DOS programs under Merge 286 also can access memory based on the Lotus Intel Microsoft Expanded Memory



Specification (LIM EMS), but UNIX cannot use this memory. The large number of utilities provided with UNIX requires a hard-disk partition of at least 17MB. The amount of memory allocated to DOS under Merge 286 is user selectable; with a 640KB DOS allocation, 552KB is available for applications. Memory not allocated to DOS may be used by UNIX applications.

UNIX/MERGE VERSUS OS/2

Many parallels are apparent between the UNIX/Merge combination and OS/2. Both support large address spaces, multitasking, interprocess communications, and multiple sessions; more importantly, both share the pragmatic view that progress in PC operating systems cannot come at the expense of DOS compatibility.

The major differences between UNIX and OS/2 are portability and availability. UNIX has been around for more than a decade, and is supported on machines from Cray large supercomputers to micros. Although multiuser, it is the operating system of choice for single-user engineering workstations from Sun, Apollo, and even IBM (the RT PC—see the December 1986 issue of *PC Tech Journal*). The operating system itself and applications written to it, thus, are portable. Indeed, IBM currently is contracting Locus Computing to develop a version of UNIX—called AIX—for the IBM PS/2 Model 80. And, AT&T, which controls the definition of UNIX System V (accepted as the standard UNIX), has recently signed agreements with both Microsoft (XENIX) and Sun Microsystems to resolve nonportable differences in UNIX implementations. In addition, the Institute of Electrical and Electronic Engineers (IEEE) is working on a vendor-independent definition of UNIX; these efforts are supported by most major UNIX vendors, including AT&T.

OS/2 was designed and written by Microsoft employees with extensive UNIX experience. Many system calls within the two environments share similar names and parameters, and both promote the use of C as the native programming language. But OS/2 is new and untested—Microsoft will have to encourage hardware vendors to adapt OS/2 to their hardware. Because it is written in assembly language and attempts to exploit the 286 to the fullest, OS/2 is not easily ported to machines with non-Intel architectures.

OS/2 and UNIX with Merge 286 also diverge in their approach to supporting DOS applications. Internally, OS/2 consolidates many of the functions for DOS and native OS/2 at the operating system kernel and device-driver level. For example, OS/2 device drivers service both native OS/2 and DOS; they operate in both real and protected mode, which eliminates the need for multiple mode switches. However, at the program level, the DOS task is effectively quarantined from any OS/2 tasks, and has only DOS-level file access to disks.

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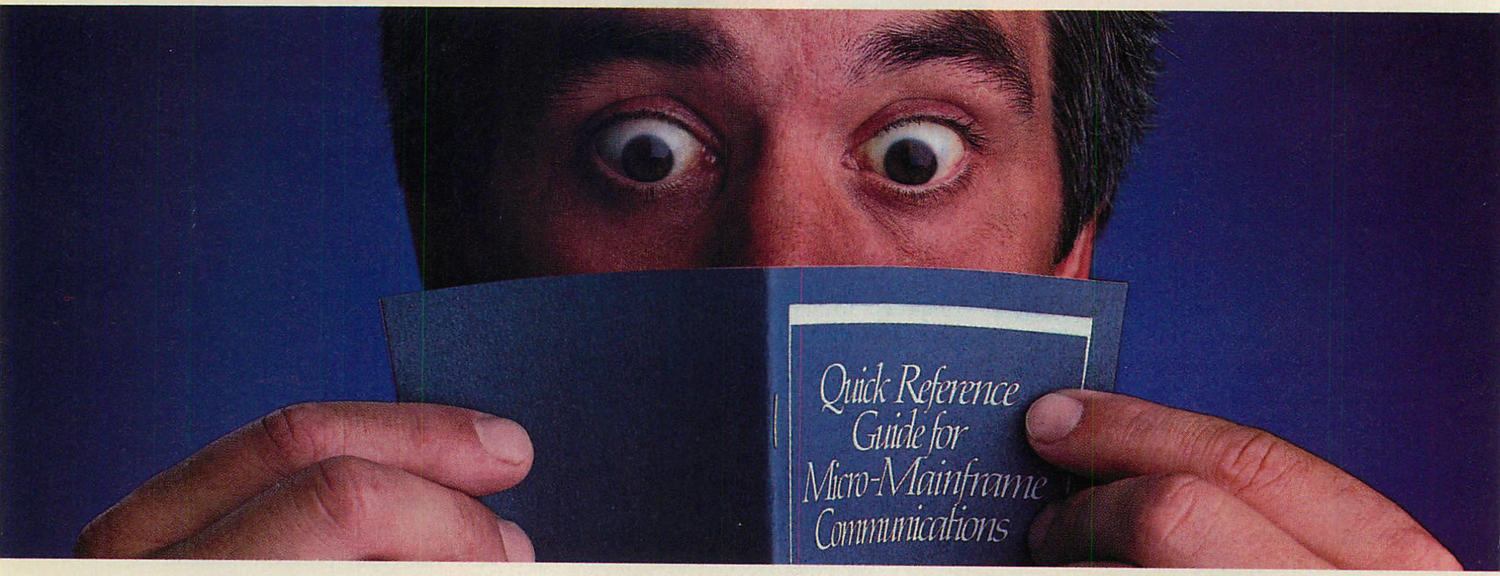

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Merge 286 takes the opposite approach. DOS compatibility in Merge is attained by running real MS-DOS; only the low-level I/O functions are affected by Merge. Inside Merge, hardware functions are allocated to either DOS or UNIX; protected mode is used for UNIX operations, and real mode for DOS. Despite this low-level separation, a DOS task has complete access to the UNIX file system, and can even be used in a pipe with a UNIX task. This is possible because DOS file I/O requests are mapped into their UNIX equivalents and performed by UNIX.

The OS/2 DOS environment is static. Parameters such as memory size for DOS and device drivers must be specified in CONFIG.SYS and cannot be changed after the system is booted. Even if a DOS program is not currently running, low memory cannot be used for an OS/2 task. If a DOS program hangs up and cannot be exited, it is not possible to reboot only DOS; the entire system must be restarted.

In contrast, Merge allows almost any parameter associated with the DOS environment to be changed at any time. The DOS environment can be rebooted independently of UNIX and UNIX can use low memory if a DOS task is not running. DOS memory requirements can be set for individual programs to use the minimum amount needed. Different CONFIG.SYS and AUTOEXEC.BAT files can be tailored for specific applications. Well-behaved (stream-oriented) DOS applications can even run in the background. Users typically do not need to know that a specific command is a DOS command; Merge transparently switches to real mode to run a DOS application that is invoked from the UNIX prompt.

WORKING WITH MERGE

The Merge 286 documentation should not daunt DOS users and will be easy for those experienced with UNIX. The *Administrator's Manual* describes installing and administering the system; the *User's Manual* is a reference for day-to-day operations and installing and removing DOS applications, system messages, and recovery procedures; the *Advanced User's Manual* (not available for this review) describes customizing the Merge 286 environment and details how Merge works; on-line manual pages (also not available), obtained through the UNIX **man** command, provide complete descriptions of commands and features.

Merge 286 must be installed after the UNIX system itself has been installed. Installation requires MS-DOS or PC-DOS version 3.1 or 3.2, which are not provided with the product. Installing Merge 286 into an existing UNIX system takes about 20 minutes and is simple, with clear prompts to guide users. During installation, the standard UNIX operating system kernel is replaced by a special Merge kernel that creates a snapshot image of already booted DOS. This DOS image is invoked each time a user enters DOS or executes a DOS command from UNIX.

UNIX is inherently a multiuser operating system, allowing multiple users to be connected to a single PC via terminals. However, architectural difficulties with the 80286 chip and limitations of dumb terminals prevent some advanced UNIX features from being used from a terminal. Only one user has full access to the DOS environment and virtual console features. This evaluation was performed assuming that the PC would be used as a single-user workstation.

Under Merge 286, many DOS commands can be accessed directly from UNIX; the reverse is true of some UNIX commands in DOS.

User interface. Many DOS commands, such as DIR and TYPE, can be accessed directly from UNIX when Merge 286 is installed, and the reverse is true of some UNIX commands when users are in DOS. UNIX enthusiasts can continue to use UNIX system commands at all times and DOS users can continue to use commands familiar to them. In addition, the system administrator can install more commands than come with the product, and all of them can be used on either file system.

Merge 286 provides users with five *virtual consoles* to run multiple tasks—four for UNIX and one for DOS. Each virtual console operates independently and occupies the entire display when it is selected. Programs running on a UNIX virtual console can continue to run in the background, even though they are not displayed. Pressing Alt-F2, Alt-F3, and Alt-F4 switches the user to the other consoles to run additional UNIX tasks. Pressing Alt-F1 returns him to the original screen.

The fifth virtual console controls the DOS environment. Users type the command **dos** to access it; typing QUIT (from the DOS prompt) returns them to the UNIX console. If users run DOS as a detached task (**dos &**), they can press a hot-key combination (Ctrl-SysRq) to switch instantly between UNIX and DOS screens. Because DOS programs typically write directly to screen memory, they often must be suspended when a UNIX virtual console is selected. However, Merge 286 allows DOS applications that are well-behaved to be installed so that they can run in the background. Compilers and stream-oriented programs such as DOS SORT can be configured this way and are even able to communicate with UNIX programs through pipes.

Invoking programs. DOS programs run from either the DOS environment or from the UNIX shell; UNIX programs also can be invoked from either system. Both methods to invoke DOS programs allow users to specify numerous parameters, such as memory space for the DOS environment, CONFIG.SYS, device assignment (DOS can control hardware devices when DOS starts or only when the devices are actually needed), print spooling, break checking, and alternative DOS load images. They can be set as global defaults to avoid constant reentering, yet can be overridden from the command line whenever desired. Different applications can have dissimilar defaults and two users can have different defaults for one application.

When users invoke DOS, the familiar C > prompt appears as well as the directory used to call DOS. The work environment appears the same as DOS, except that users have instant access to both UNIX and DOS disk partitions and file systems and the additional features of UNIX. With COPY, DOS files are copied into any directory on the UNIX partition, and vice versa. Locus and Microport encourage exclusive use of the merged DOS/UNIX partition, claiming that all programs run in this partition except those with copy protection or those that manipulate the FAT.

Commands issued from the UNIX prompt use UNIX pipes which, unlike DOS, start two programs simultaneously. The following command issued from the UNIX line simultaneously invokes DOS DIR and UNIX **sort**:

```
$ dir a: | sort
```

Display-oriented or stream-oriented. Merge 286 is configured by default for display-oriented programs (applications

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that require interaction with the user and often use direct screen writing); however, it also distinguishes and handles stream-oriented programs. A UNIX screen is used for UNIX applications and can be used for DOS stream-oriented programs; a DOS screen is used for both display- and stream-oriented programs.

Merge/UNIX runs stream-oriented DOS programs, from the UNIX screen with UNIX pipes and redirection utilities, because program I/O traverses several layers of software between the program and hardware. Merge intercepts I/O when it reaches DOS and gives its control to the UNIX I/O pipe and redirection mechanisms. Merge cannot intercept output of display-oriented programs (DOS screen) because the program moves directly from hardware, circumventing DOS.

The UNIX commands **at**, **batch**, and **nohup** can be used with DOS processes. The **at** command runs DOS or UNIX commands at a later specified time, **batch** executes specified processes when the system load allows, and **nohup** executes processes immune to hangups and quits. For example, to run a dBASE II update function at 8 p.m., a user could enter:

```
$ at 2000
dbase update
```

Drive assignments. Four drive designations are available for accessing the hard disk—C:, D:, E:, and J:. Drive E: is the DOS partition, which allows users to work on a DOS-formatted disk for programs that require it. Drives C:, D:, and J:, are mapped to the UNIX file system. Drive C: corresponds to the root directory of the UNIX file system; D: is set to the user's home directory and thus is useful for installing and running DOS applications that modify or create files in the root directory. By using D:, applications modify or create files (AUTOEXEC.BAT or CONFIG.SYS) in a user's home directory rather than in C:, the system-wide root directory. Drive D: is unique for each user. Drive J: allows access to everything on C: and provides an alternative logical drive for running DOS applications that require program or data file access from the current directory.

UNIX and DOS have entirely different procedures for accessing diskette drives, but both are accommodated by Merge. UNIX requires that a diskette be mounted using the **mount** command before it is used, so that the system can buffer diskette data. As part of the UNIX file system, a diskette drive then can be accessed as a UNIX directory from UNIX or DOS, usually named **/mnt**. Before the diskette is removed from the drive, it is unmounted to write any buffered data to the diskette.

Diskette drives A: and B: are accessed as they normally are in DOS, unless they have been mounted as UNIX devices before starting DOS. In this case, users accessing a diskette from DOS as A: or B: are given a "Drive not ready" message. If a diskette is mounted as a UNIX device and a user decides midstream in a DOS session to access it as a DOS device, he can switch to a UNIX screen, unmount the diskette, and return to DOS.

When the user creates a directory, UNIX file names, which are in upper- and lowercase and allow more characters than DOS (System V allows 14), must be mapped onto the 11-character uppercase file names (8 in the file name with a 3-character extension) permitted under DOS. This is accomplished using various abbreviations. For example, the UNIX file name **message.tobob** becomes MESS'BBF.TOB in the DOS directory listing, and **a.b.c** becomes A_B'SV.C. If UNIX file names are also legal DOS file names, no mapping takes place. UNIX names illegal under DOS can be renamed to legal DOS names via the UNIX **mv** command accessible from DOS.

The DOS environment for each UNIX user can be customized—users can execute their own CONFIG.SYS and AUTOEXEC.BAT files.

In UNIX, each user has a home directory. When logging onto UNIX and entering the DOS environment, the work directory is set to the user's home directory (for example, **/usr/bob**). By default, users can obtain a directory listing, read or copy a file, run programs in any directory; however, users cannot delete or modify files in any directories except their own. These default permissions can be changed easily using UNIX **chmod**.

Customized DOS environments. Under Merge, the DOS environment for each UNIX user can be customized—users can execute their own CONFIG.SYS and AUTOEXEC.BAT files when starting DOS. Customized features available to DOS under UNIX with Merge include: break checking on or off, designating amount of DOS memory, assigning or canceling DOS device assignments, setting initial current drive, spooling DOS printer output to UNIX with a selectable time-out value or having DOS handle printer output, and clearing screen at DOS start-up or copying the current UNIX screen.

A user's account also can be configured so that upon logon to UNIX, the user enters DOS or a DOS application directly without going to the UNIX shell. A user's DOS environment can be open to the entire system or restricted to an application and user directory. This flexibility could be useful, for example, in a classroom situation of 20 students and only 5 ATs. Students could have limited access to the DOS environment; they might have the ability to access some programs and use their personal secured directories, but not to use files of other students.

Advanced printing. Under Merge 286, output is fed to printers by DOS or UNIX; parameters can be set up as default and changed anytime during the DOS session. The **printer dos** command gives DOS control of all output. When printing is done under UNIX, DOS printer output can be saved for future printing or deleted.

Printer unix sends all printed output to the UNIX spooler, where it can be controlled by UNIX commands. For example, one command causes output to a PostScript-compatible laser printer, while a second command directs other output to a line printer.

Translating command-line arguments. Merge accommodates the command style of the operating system being used—when typing at the UNIX prompt, UNIX syntax is used, even for DOS commands. At the DOS prompt, path separation and switch characters operate exactly as they do under DOS. For example, users wanting wide-format DOS directories type, as usual, at the DOS prompt:

```
C> dir /w
```

They can get a DOS-style wide directory of whatever UNIX directory they are logged into by typing the following at the UNIX prompt:

```
$ dir -w
```

This can lead to problems, but only when DOS programs with many path or switch arguments are invoked from the UNIX prompt. Merge has an option that prevents it from translating DOS

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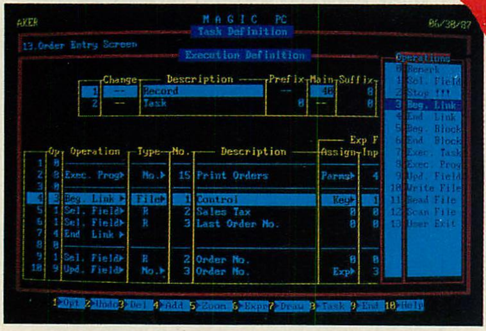

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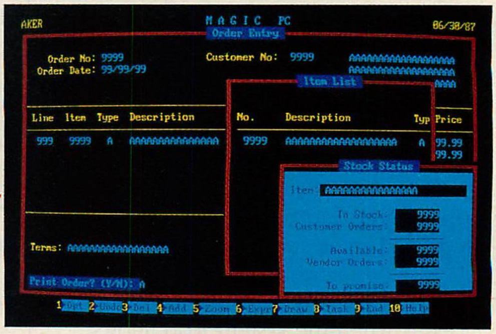

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commands invoked from the UNIX prompt. The Merge manual gives an example of a hypothetical program called **compute**, which performs simple arithmetic. Normally, Merge would translate the command

$ compute 8 − 4

to

$ compute 8 / 4

This can be prevented with the following command:

$ dos -t compute 8 − 4

The "t" switch, like all other Merge switches, can be set as a default, which can be overridden at the command line. Of course, when **compute** is invoked from the DOS prompt, no conflict will result.

Compatibility. Although UNIX System V/AT runs on most AT compatibles, Merge 286 is more machine-specific and sets a new level of difficulty for AT compatibility. One reason for this difficulty is switching between real and protected modes on the 80286 chip, which is not faithfully implemented by all AT compatibles (see the sidebar below by William Tropp entitled "Mode Switching in 80286 Processors" that accompanies this article). Microsoft has a similar dilemma with OS/2, but has elected to make each hardware vendor responsible for providing a customized version of MS-OS/2 that works with its own hardware.

Machines modified for OS/2 compatibility are likely to be Merge 286 compatible. For example, early Compaq machines could not run Merge 286 until Compaq provided updated hardware in the keyboard controller to aid mode switching; the machines now run both Merge 286 and OS/2. Zenith is also modifying its older AT compatibles. The IBM PS/2 Models 50 and 60 and the new Chips and Technologies AT chip sets have included features for rapid mode switching.

Merge 286 appears to run most software that has been developed for DOS 3.x without problems. Terminate-and-stay-resident (TSR) programs such as Borland's SideKick worked well with Micropro WordStar and Lotus 1-2-3.

MODE SWITCHING IN 80286 PROCESSORS

The Intel 80286 can be operated in real mode or virtual protected mode. In real mode, it behaves as an 8086, but with added instructions. In virtual protected mode, it also performs address translation and address checking, which are essential for implementing a secure multitasking system and increasing the processor's addressing range from 1MB to 16MB. Because software for the 8086, including DOS applications, does not run in virtual protected mode, Merge 286 runs UNIX in protected mode and switches to real mode to run DOS.

However, a software instruction cannot switch the 286 from virtual protected address mode to real address mode. The chip's reset line must be activated to reset the processor to its power-on condition. On the IBM PC/AT, this is accomplished by issuing I/O commands to the 8042 keyboard controller or causing a triple-fault condition.

The triple-fault condition is entered in cases of extreme software malfunction and should never occur during normal operation of the processor. In protected mode, it can be forced by setting to zero the limit of a critical protected-mode system table, the interrupt descriptor table (IDT), which contains the addresses of exception and interrupt handlers. A software interrupt instruction is then executed to cause an access to the IDT to obtain the address of the interrupt handler. The IDT entry is, however, beyond the current addressing limit.

This causes a general protection (GP) fault and the processor attempts to obtain the address of the GP handler from the IDT. But because the IDT limit is still zero, accessing the GP vector causes an error condition, this time raising the double-fault condition. (The software interrupt caused the first fault; inability to enter the GP handler caused the second.) Again, the IDT is accessed to obtain the address of the double-fault handler and that vector, too, is beyond the IDT limit. This causes a triple fault, indicated by a particular combination of the address and status lines. The condition is detected by circuitry on the AT system board connected to the chip's reset pin, which then initiates a processor reset.

The 286 begins running in the ROM BIOS after reset; it is necessary therefore to exploit the ROM BIOS to effect transfer to the DOS Merge code. When the UNIX scheduler attempts to run DOS, a stack is set up to mimic the extended-memory-block-move BIOS call (BIOS interrupt 15, function 87H.) The call moves data to or from extended memory by entering protected mode, performing the transfer, and returning to real mode by placing a special code in CMOS memory and resetting the processor.

Once reset, the processor executes in the ROM BIOS in real mode. The BIOS code checks the shutdown byte in the CMOS and determines that it is a return from an extended-memory-block-move BIOS call. It pops the stack and continues execution at the point where the BIOS call was first invoked. In DOS Merge, the stack is faked to return to the Merge switch code, and returns control to the DOS program.

In addition to performing the protected-to-real mode switch properly, a compatible ROM BIOS also must ensure that all BIOS data areas are properly set. Another area of compatibility, independent of the ROM BIOS, is the ability of the keyboard controller to quickly toggle a signal line that controls the action of a bus address line.

The 286 permits addressing above 1MB in real mode by loading 0FFFFH into a selector and using an address offset that is greater than 0FH. To ensure compatibility with existing 8086 computers, IBM added circuitry that causes the A20 address line on the AT bus to be held to zero or follow the A20 line that is generated by the chip.

In real-mode operation, the A20 bus line is disabled (tied to zero). Any attempt to address beyond 1MB wraps around to low memory, as does an 8086. In virtual protected mode, all address lines must be used and wraparound is undesirable. A sequence of I/O instructions to the keyboard controller enables the A20 line to allow access to memory above 1MB. Because the ROM BIOS code disables the A20 line when Merge switches to real mode, it must be reenabled when switching back to protected mode to run UNIX.

Some keyboard controllers do not toggle the A20 line quickly, causing UNIX to fail upon returning to protected mode. Several compatible manufacturers have taken steps to rectify this problem with a keyboard controller update kit.

—William Tropp

SideKick also worked with earlier versions of XyQuest's XyWrite III, which are notoriously difficult to mate with TSRs. Even programs that take direct control of DMA channels appear to work, including Fifth Generation System's Fastback and the device driver for the Iomega Bernoulli box, which uses a DMA channel.

Areas of incompatibility include communications programs and timing-dependent games. Microsoft Windows 1.03 runs under Merge; this is notable since it does not run under OS/2's DOS compatibility environment. DOS applications that do their own mode switching, such as IBM's VDISK driver, any DOS extender, and Oracle Corporation's ORACLE, cannot be used.

Copy-protected programs run successfully, including those requiring a key disk in the diskette drive. Programs that directly manipulate the DOS file allocation table (FAT) must be installed to use the DOS partition (drive E:) rather than the shared UNIX/DOS partition (C: and D:).

Importantly, the integration between UNIX and DOS seems solid and reliable. For example, users can hot-key out of DOS in the middle of writing a long file to the hard disk, and disk activity ceases. They can then execute any UNIX processes, including those writing to hard disk. When they hot-key back to DOS, the disk write continues without losing a byte.

If, while in UNIX, users kill the DOS process with **doskill**, or execute a system shutdown, the write is canceled. Two scenarios can occur, depending upon whether the write was to the DOS partition or the UNIX partition. In the DOS partition, the directory shows a file of zero bytes. In the UNIX partition, it shows a file of however many bytes were written to disk before the process was suspended; this partial file is accessible. The reason this happens is that in the DOS partition, the directory entry is updated at the "close" operation, which never occurs if **doskill** is used. On the UNIX file system, a UNIX close occurs automatically even if the DOS process is killed.

The Merge 286 manual lists several software restrictions. It states that DOS applications must not:

- Act in ways that might crash DOS; for example, by turning off interrupts and halting or looping.
- Write to memory that it is not assigned. A program does not violate this restriction if it remains within memory limits specified by either DOS or BIOS data.
- Access the hard-disk registers directly. They must not access or affect channels of the DMA controller or DMA page registers that are associated with the hard-disk controller. A program that uses DOS or the BIOS does not violate this restriction.
- Change the mode of the interrupt controller, but they can change the interrupt controller vector base and the mask register, and perform specific and nonspecific end-of-interrupt (EOI). They cannot, however, rotate interrupt priorities or change the interrupt mode and should not mask or unmask interrupts for devices they are not using.

Merge 386 solves the Merge 286 limitations of running only one DOS task at a time and debilitating crashes of the system.

- Use the realtime clock, however, they can make use of the normal timer clock on interrupt 0.
- Write to the calendar clock.
- Attempt to enter 80286 protected mode or use special 80286 instructions that are designed to support protected mode.
- Return from a hardware interrupt routine on a different stack than the one on which they entered. This is done by some programs that attempt multitasking within themselves.

The DOS application cannot use interrupts 13 (ROM BIOS diskette services), 25 (absolute disk read), or 26 (absolute disk write) for accessing the shared DOS/UNIX file system, but it can use them to access the DOS partition.

Some DOS programs disable interrupts for fractions of a second. This can disrupt time-sensitive UNIX functions, such as serial input. For example, if **uucp** is running at 1200 baud and receiving a file over COM1, then the UNIX serial driver gets one interrupt every 8 milliseconds. If a DOS program is running and disables interrupts for longer than that time, characters can be lost, and **uucp**, notified of errors, must retry the packet. This degrades **uucp** performance and might cause it to abandon transfer.

The additional processing performed by Merge 286 adds approximately 100 microseconds to the delivery of hardware interrupts if the processor is in real mode at the time of interrupt. This lengthens effective time of all interrupt routines and can affect some time-critical devices. If the processor is in protected mode at interrupt, the delay is longer; its length is not affected by the number of tasks that are running.

The most common manifestation of this problem in Merge 286 is with serial communications in a DOS task. Using high-speed serial communications (modems or terminals) in DOS with multiple UNIX processes running might cause the DOS task to lose characters as the UNIX load increases. This can be circumvented to some extent by increasing the priority of the DOS task with the **nice** command.

Caution should be exercised when using DOS utilities that might make significant changes to the UNIX file system. For example, DOS BACKUP and RESTORE should not be used, because the files involved will be restored without correct permissions, ownership, or group, and files that originally had illegal DOS names will be restored with Merge-mapped names. UNIX has equivalent programs for archiving files that understand the structure of the UNIX file system.

Merge 286 has two major limitations that also apply to OS/2, but that Merge 386 solves: it runs only one DOS task at a time and a crash can bring down the entire native operating system. In Merge 286, the standard Ctrl-Alt-Del combination often kills the DOS task and returns users to UNIX without crashing, so they can reboot DOS instantly within UNIX.

If UNIX crashes, recovery with System V/AT's hardened file system is transparent. All necessary software and responses automatically run when users reboot so that only data that were not written to disk are lost.

Speed. Table 1 shows the results of tests comparing the performance of a system running UNIX with Merge 286 against the same system running only DOS. The Eratosthenes Sieve benchmark was used to determine the relative performance degradation of a task that was mostly CPU-bound. A decrease in runtime speed of about 15 percent was observed.

Accurate and repeatable measurements of disk-intensive applications were much more difficult to obtain because UNIX uses disk I/O optimizations. One optimization—caching—significantly reduced the time needed

TABLE 1: *Merge 286 Performance Tests*

	DOS	MERGE 286 DOS PARTITION	MERGE 286 UNIX FILE SYSTEM
Sieve (100 iterations)	27	33	33
Norton Disktest (reads a 360KB diskette)	91	92	N/A
Read a 200KB text file from hard disk using XyWrite III+	5	9	14
Save 200KB text file to hard disk using XyWrite III+	15	36	16

N/A = Not applicable.
All times are in seconds.
Tests were performed on an NCR PC 8 (8-MHz 80286) with 4MB of extended memory and a 20MB, 40-ms hard disk.
The Sieve benchmark for DOS was compiled with the DeSmet C compiler, version 2.3.

CPU-bound programs such as the Eratosthenes Sieve are degraded by about 15 percent under Merge with no active background (UNIX) processes. Low-level I/O is not greatly affected, as shown by the Norton Disktest result. But DOS file I/O is noticeably slower. Buffering and write-behind help mitigate the performance degradation when the UNIX file system is used, as shown by the XyWrite results.

to perform the test after the first run. The times shown in table 1 were performed after a system boot to ensure the cache did not affect timings. In this respect, the times shown here are worst-case; during typical use, the cache will improve disk I/O.

A second optimization, called write-behind, is less common in the DOS environment. To improve performance for disk-write requests, UNIX copies data from the program-supplied buffer into a system buffer and returns a success code to the program, which then can continue. Barring a catastrophic failure of the disk or system power loss, the data are later written to the disk. The effect of write-behind optimization is shown in the XyWrite file save test. Even after XyWrite returned from writing the file, disk activity continued for a few seconds. During that time, it was still possible to type and issue other commands, but response was slightly slower.

Clearly, increased DOS performance is not a reason to use Merge 286. Considering the power provided by Merge, the performance compared to DOS by itself is respectable. UNIX disk optimizations also help to mitigate the effect of passing through the many layers of software to reach the disk.

BEHIND THE SCENES

A look behind the scenes at the operation of Merge 286 with UNIX provides insight into the difficulties of integrating two divergent operating systems. When Merge 286 is installed, the kernel is modified so that UNIX starts from high memory (extended memory) and moves downward as necessary. DOS and unmodified UNIX do the reverse. Using memory from the top down in this way is designed to reserve base memory for DOS.

After power-on, the UNIX system boots as standard UNIX would, except that the Merge kernel immediately relocates to high memory, leaving low memory free for DOS. A memory map for UNIX with Merge is shown in figure 1. DOS can access under Merge 286 all physical memory below 640KB. If no DOS process is running, UNIX can occupy the memory that DOS would have used.

When a DOS task is invoked, Merge 286 relocates UNIX tasks that are running in the DOS space and the DOS image created during Merge installation is loaded into low memory. Initialization parameters are placed into shared memory, then the processor switches to real mode and performs DOS initialization. Next, the command processor (COMMAND.COM) is called to either execute a single command or provide a command-line prompt for interactive use.

DOS applications normally do not attempt to write outside the range of memory given to them. Because UNIX writes from the top down and DOS from the bottom up, if a DOS application writes beyond its memory, the chances are slim that it will corrupt UNIX. For UNIX to write in the lower area, which is generally reserved for DOS, the system would have to be heavily loaded or have only a small amount of physical memory. If a DOS application does write outside its allotted memory, this memory-allocation scheme makes finding the problem difficult because it will crash the system intermittently, and only when the system is heavily loaded.

The bridge and server. Two software drivers, the bridge and server, are at the heart of Merge. They perform for DOS both file I/O and remote UNIX program execution. Figure 2 shows how the bridge and server integrate the DOS and UNIX environments. The bridge intercepts DOS file I/O at a high level (interrupt 21H), and creates transactions that are passed to the server running under UNIX. The server performs I/O on the integrated DOS/UNIX file system. Transaction information is passed through shared memory. A DOS device driver, ULINK.SYS, has a transaction buffer accessible to the server.

When the bridge wants to send a transaction to the server, it formats a transaction packet containing control information and data and stores it in the transaction buffer in ULINK.SYS. Merge code then reenters protected mode and wakes up the server, which determines from the transaction buffer that there is work to do; it then performs the transaction, and reschedules the DOS task.

The server also contains a mechanism to handle file name differences in the integrated DOS/UNIX file system so that DOS has access to all files in the UNIX file system even if the file does not have a valid DOS file name. The server maps UNIX file names that do not fit the DOS file-naming scheme into names accessible to DOS applications. For example, the file called UNIX_File_Name might be accessible to DOS as UNI'BQQ.NAM. (BQQ is a unique code based on the UNIX i-node number of the actual file.)

The server allows DOS applications to open files through either file handles or old-style file control blocks (FCBs). UNIX generally permits only 20 open files per process, but the server implements a cache that circumvents this restriction. When new file descriptors are needed, open files are "swapped out," then restored to their prior state when next accessed by the DOS application. The server also maps backslashes to forward slashes in path names, enforces UNIX file permissions, and maps UNIX error codes to the appropriate DOS error codes.

Merge 286 uses two hardware devices exclusively controlled by UNIX: the system clock and the hard disk. Devices including COM1, COM2, parallel ports, and diskette drives, can be controlled by either system. Merge 286 automatically allows shared devices to

be controlled by DOS unless UNIX is using them. The only device controlled exclusively by DOS is the DOS timer.

The UNIX clock interrupt causes the UNIX scheduler to run, which controls UNIX time slicing. To the UNIX scheduler, the DOS process is just another time-sliced process. The bridge, server, DOS, and DOS application are viewed by UNIX as one of its processes, and have the same permissions as the user running that process.

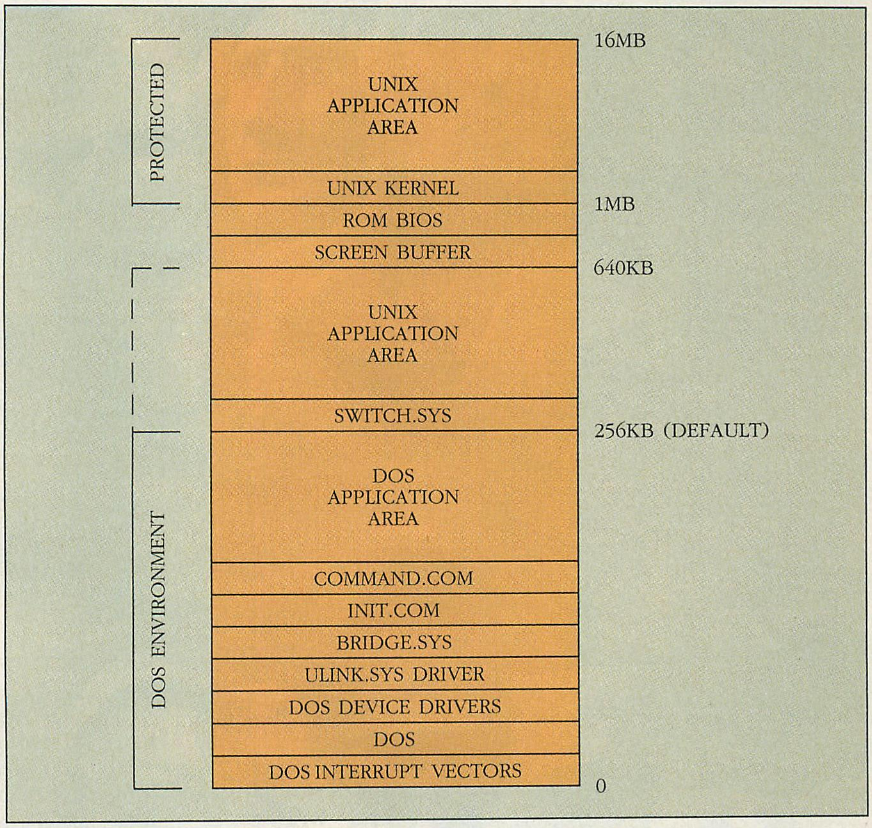
Switching between DOS and UNIX. As it processes requests from both UNIX and DOS, Merge 286 must switch between the protected mode used by UNIX and the real mode of DOS. One reason Merge switches between processor modes is to deliver an interrupt or return from an interrupt. Each device, such as clock, serial interrupt, printer interrupt, diskette, or hard disk, is assigned to either UNIX or DOS. When one device interrupts, the code catching the interrupt determines what operating system the device is assigned to and delivers the message to the appropriate system's interrupt routine.

If the hard-disk interrupt occurs while a user is in DOS (the hard-disk interrupt is always under UNIX control), Merge code catches the interrupt, switches to protected mode, and delivers the interrupt to the UNIX disk driver. If the user is already in protected mode and the hard-disk interrupt occurs, Merge code delivers the interrupt directly to the UNIX disk-interrupt routine. If it is in protected mode when the DOS timer interrupt occurs, Merge code switches to real mode and delivers the interrupt to the DOS side. When interrupt processing is complete, Merge returns to the processor mode in effect at the time the interrupt occurred.

This device-handling approach is different from OS/2, where device drivers must be written so that they can be run in both protected and real mode. In real mode, the OS/2 kernel passes paragraph addresses in the segment registers to the driver; in protected mode, segment selectors are passed. The primary advantage of the OS/2 approach over the Merge approach is that fewer mode switches are required; performance should be better in OS/2, especially for frequent-interrupt devices such as serial ports.

Besides managing interrupts, Merge switches modes to allow executing DOS to perform disk operations such as reading a file on the UNIX-controlled file system. For example, if a user wants to open a file on drive C:

FIGURE 1: ***UNIX/Merge Memory Map***



Merge uses low memory to create a DOS environment. If a DOS environment of less than 640KB is requested, UNIX can use the remainder of 640KB. Device drivers in low memory intercept calls, translate them into requests to the UNIX kernel, and switch to protected mode. Without Merge, all memory is available to UNIX.

(the UNIX file system), the bridge intercepts the call, examines it, identifies it as an open call for drive C:, and passes the open request to the server (see figure 2). The server makes the UNIX open system call to the UNIX kernel, the kernel returns a file descriptor, and the information is sent through the server and bridge to the DOS application.

To read the file, the application does a read system call using the file descriptor, information such as number of bytes to read, and an address to locate the bytes. The bridge intercepts the system call, recognizes the descriptor as one of its own, and passes the read request to the server, which performs the UNIX read system call and passes the data back to the application.

When writing to the DOS partition only, the bridge passes the write request to DOS, which passes a sector-level write request to a DOS device driver. The driver requests that the server perform sector-level reads and writes to a UNIX special file that represents the DOS partition. Thus, UNIX retains total control of the fixed disk I/O, reducing chances of a DOS program accidentally writing to the wrong part of a disk.

Switching screens. The action of pressing Ctrl-SysRq to switch between active DOS and UNIX windows generates an interrupt. When changing from DOS to UNIX, Merge 286 switches to protected mode, saves the current DOS screen buffer contents, and restores the UNIX display buffer contents, including the appropriate video mode. Switching from UNIX to DOS, the video mode is retrieved from the BIOS; this information might be incorrect if the DOS application has directly changed the video mode by direct hardware access. A *switchmode* function is provided so the user can manually set the correct video mode when this problem occurs.

When running programs in the UNIX background and using a DOS program (such as a text editor) in the DOS window, console I/O slows substantially. This behavior is typical of DOS programs that chew up a lot of CPU resources by polling the keyboard. It is a situation that can be mitigated somewhat by giving DOS a higher

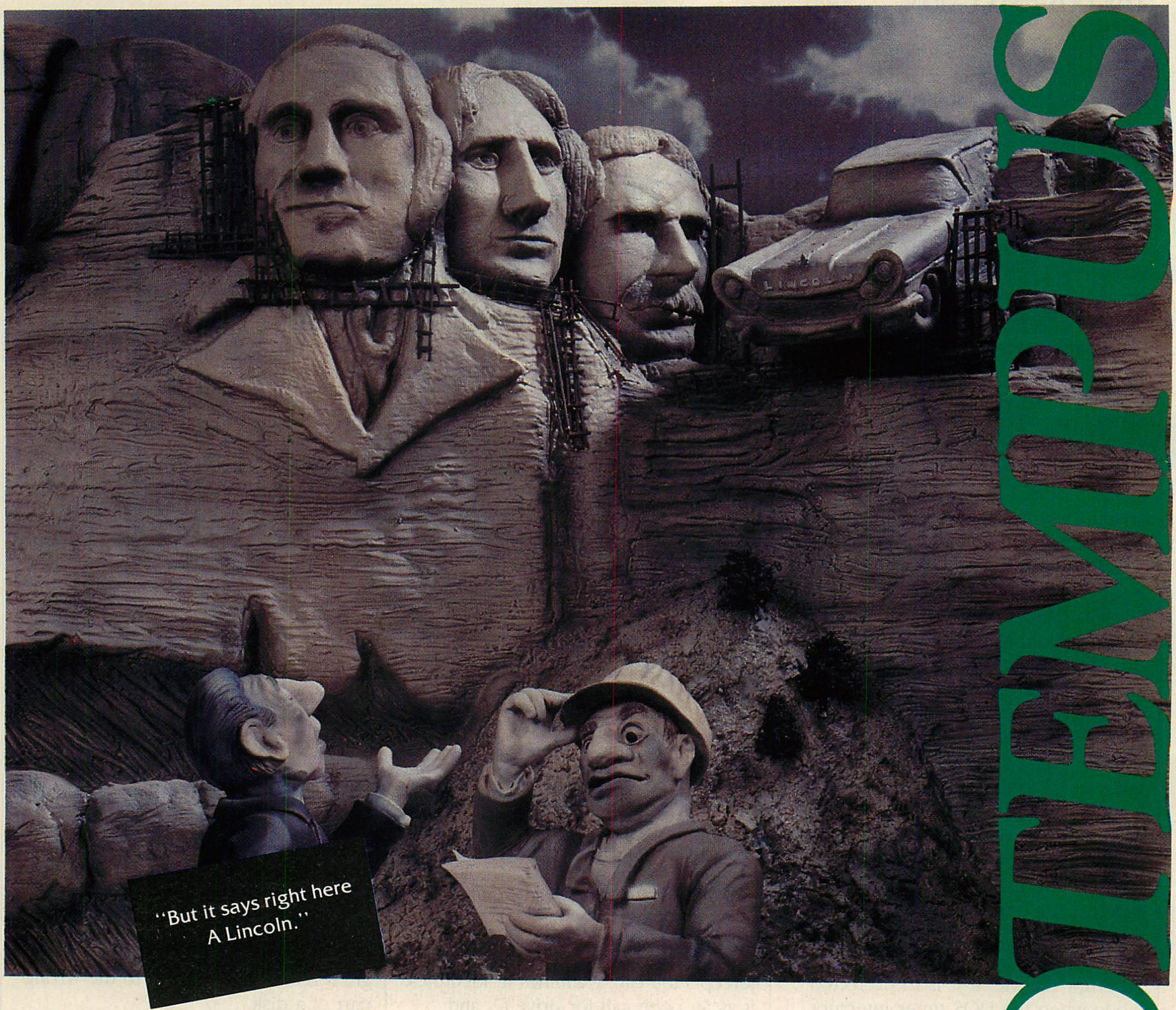


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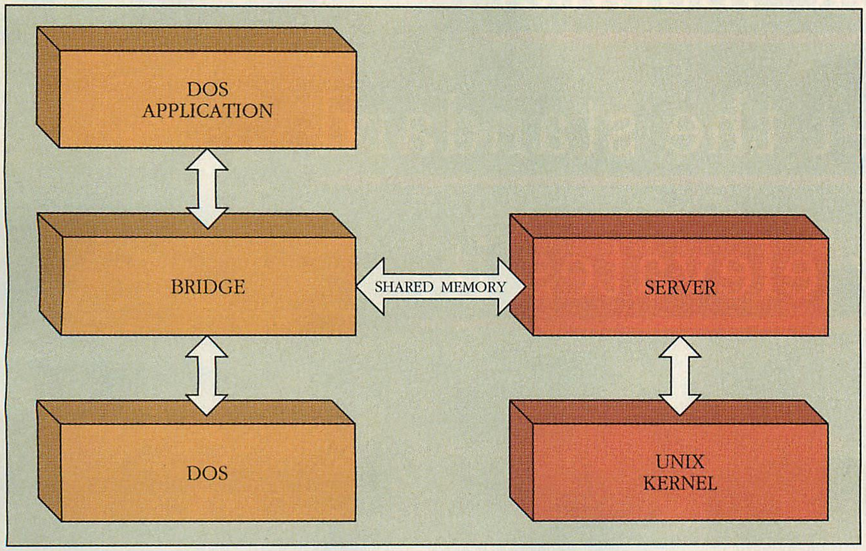
FIGURE 2: *DOS Calls under Merge 286*



When a DOS application makes a call to DOS through interrupt 21H, it is intercepted by the bridge. If the call requires action by UNIX (such as access to a UNIX file), the bridge creates a request packet and sends it to the protected-mode server. The server performs the request and returns a response packet.

scheduling priority with the **nice** command, but ultimately it needs to be corrected by Microport or Locus in a later release of the product.

Files and protection levels. The protection levels used by UNIX are categorized as *owner*, *group*, and *world*. Owners are creators of a file or directory; groups are ad hoc entities formed and administered by system administrators, so members can freely access each other's code; and world consists of any other users on the system. Within each protection level are layers of privilege: read, write, and execute. Each file is given a protection mode specifying the privileges granted to each protection level.

DOS files in the UNIX partition can be assigned different protection levels; this is not true for those in the DOS partition, except for the rudimentary protection available under DOS, such as read only, which can be set in the DOS partition under Merge 286 as it is under a standard DOS system. The system administrator can extend or restrict permissions and users can extend or restrict permissions for their own directories and files.

If a DOS partition is on the hard disk, Merge 286 accesses it as drive E:. The partition is designed for public use although it can be limited to specific users. Because it is actually mapped into the UNIX file system as a special file called **/dev/dsk/dos**, it can be assigned to a specific user or group, or can be made read-only.

COMPETITIVE PRICING

The price of UNIX with Merge 286 is one of its most attractive features. UNIX System V/AT is sold in three parts: the runtime system costs $199 and comes with a two-user (two-person) license; text preparation costs $199; and software development, $249. A $100 discount for all three parts purchased together amounts to $549 for the total UNIX product. An unlimited user license is an additional $249. Merge 286 costs $149 from Microport.

The runtime system provides the operating system kernel plus many of the famous UNIX programs such as the **awk** programming language and some of the better Berkeley variants, such as **vi** (the full-screen programming editor), and the C-shell. The UNIX-to-UNIX communications packages (**uucp** and **cu**) are also included.

The latest release of the runtime system also features System Vision, an easy-to-use program that performs most system administration tasks by simple menu selections. System Vision has the potential to overcome one of the main obstacles to UNIX acceptance: it allows comparatively uninitiated users to perform basic system maintenance with ease. System Vision enables users to write easy, menu-driven applications for UNIX and to solve system problems that previously required the attention of persons with special expertise.

The software development system includes **sccs**, **make**, **yacc**, **lex**, **sdb** (symbolic debugger), as well as compilers for C, FORTRAN 77, and RATFOR. Microport UNIX uses AT&T's Common Object File Format (COFF) as opposed to the Intel Object Module Format (OMF) used by XENIX. No object-level compatibility exists between systems, but Microport supplies **sdb**, an important debugging tool.

The text preparation system is UNIX's Documenter's Workbench Version 1, which consists of **nroff** and **troff** (the new version, **di-troff**, producing a device-independent ASCII page layout language), the standard document formatting macro package, the **pic** graphics language, and the mathematical typesetting program, **eqn**.

MERGING WITH THE FUTURE

Merge 286 will be invaluable to UNIX users who also need to run DOS applications. It is also possible that the availability of Merge 286 will spur the demand for UNIX from developers that need a better development environment, but are hesitant to leave the security of DOS. The complete UNIX package from Microport is priced attractively, and certainly is worth a look.

The important choice to be made is one of operating systems. Without a crystal ball, it is difficult to predict the trends of the next few years, but surely DOS is the dominant operating system on PC compatibles today. Although OS/2 is new and unproven, it is championed by industry giants Microsoft and IBM (see the November 1987 cover suite, "Enter OS/2," which includes articles on several aspects of this new environment). But there is much to be said for UNIX, which has been around for a long time, is well established, and has a strong base. Adding fuel to the fire, even Microsoft and IBM actively sell versions of UNIX. The bottom line: if UNIX and DOS, in that order, are important to you, take a look at Merge 286; if not, keep looking.

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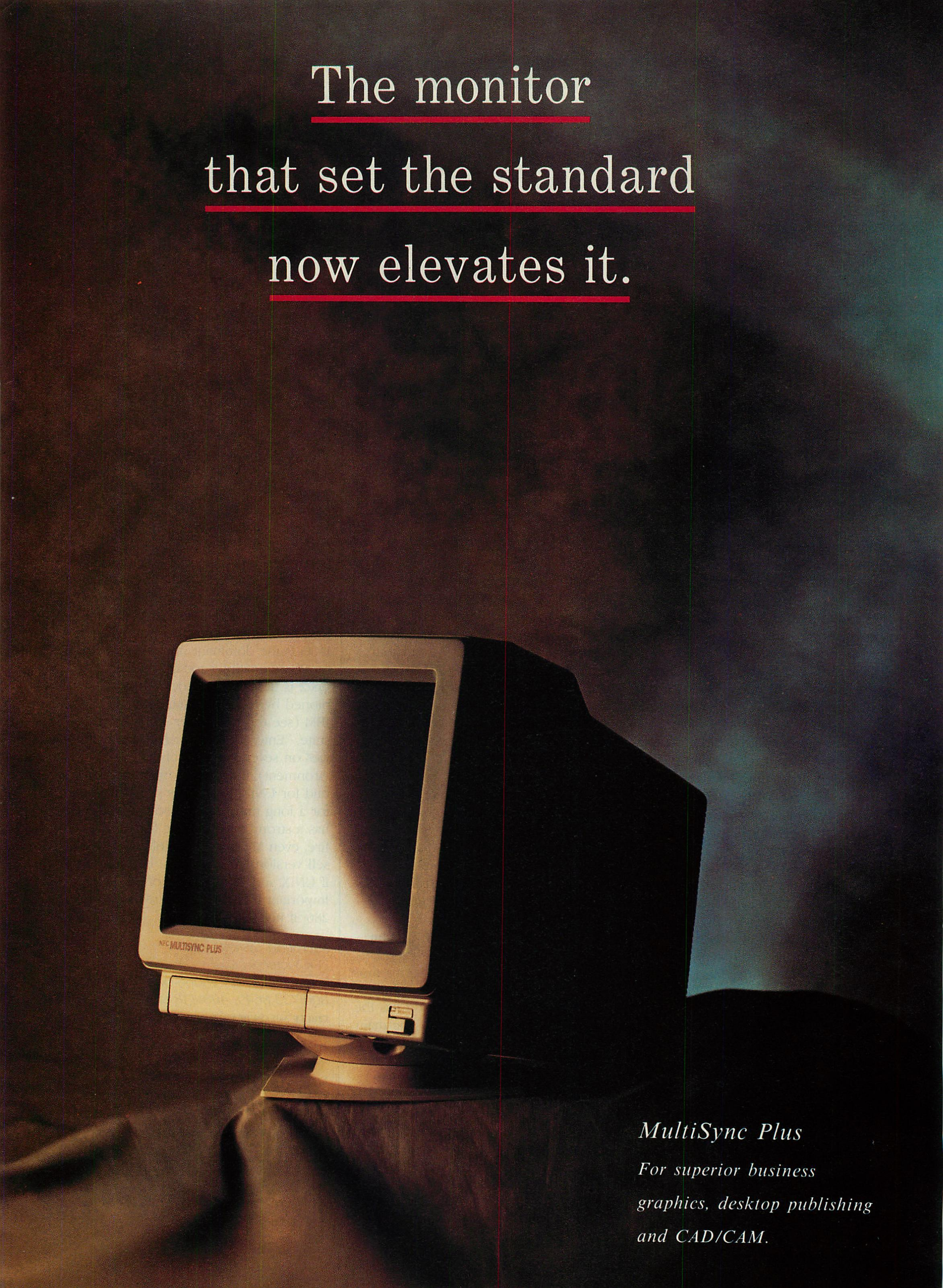
William Tropp is an independent computer consultant in New York City. Stephen Wright is a systems analyst for AGS Computers Inc., a consulting firm in New Jersey.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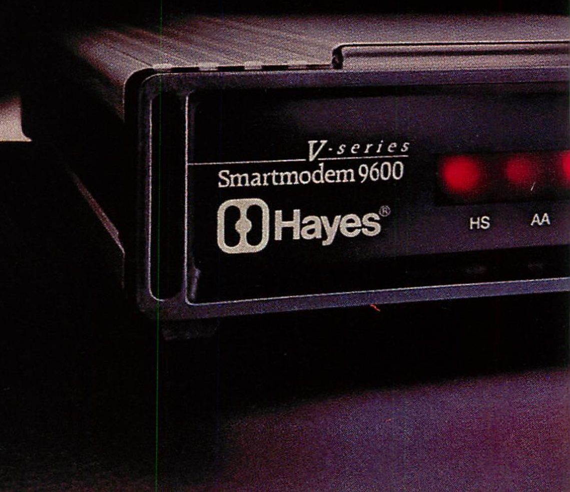

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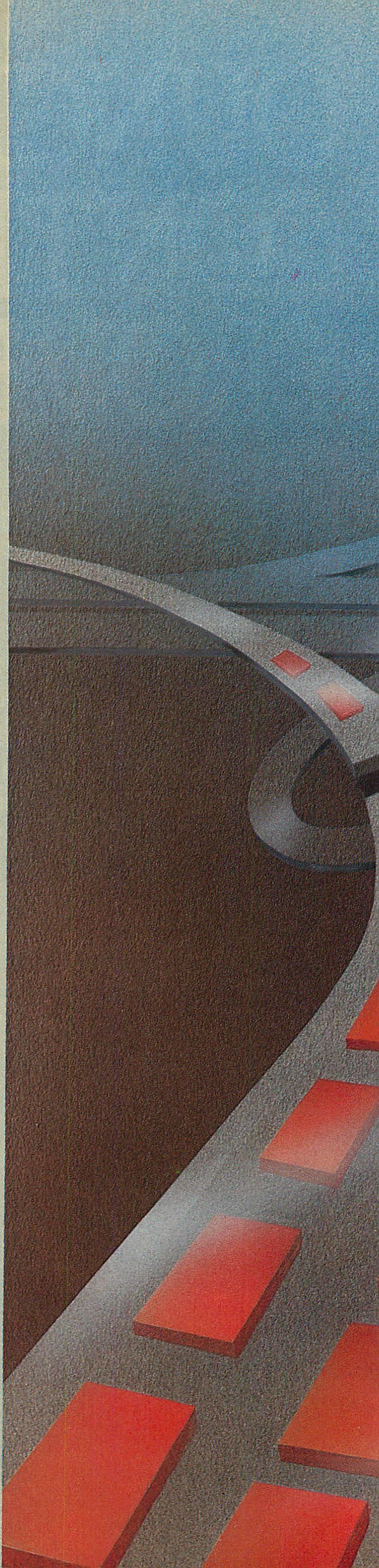

LAN Security

As local area networks start to proliferate within the corporate environment, so do the demands for security.

ART KRUMREY

Many corporate microcomputer managers are uncomfortable about installing a local area network (LAN) in offices that require rigorous security. The sight of the network plug on the back of the PC hooked to a common cable and the mere mention of the words "data sharing" are enough to scare some department heads into keeping their PCs off a network. Are these concerns justified and reasonable?

A LAN populated with high-speed AT compatibles and the newest 80386 machines certainly has the raw horsepower to match a minicomputer or a mainframe. Further, a number of good PC network applications are available. That leaves security, not hardware or software, as the major obstacle to LANs for many organizations.

The innovations that have increased the ways PCs can share data have, in fact, increased the number of security issues. Gateways and bridges do wonders in providing wider access to resources, but also multiply the risks and increase the need for vigilance.

Security can be compromised, intentionally or accidentally, by internal personnel—employees, contractors, or even the LAN manager. Outside competitors, market analysts, and hackers also can gain access to the network by using either a workstation on the LAN or a modem, in the event that the LAN has dial-in connections.

Many of the security problems and solutions in the LAN environment parallel those in the minicomputer and mainframe world. The LAN adds to these some unique problems of its own. The most formidable challenge is in the way LANs distribute information. Clever intruders can monitor the high volume of information as it travels over cable between workstations and to network servers. In addition, LAN servers are often placed unattended in open office settings. Information also can be removed easily from unsupervised printers and diskette drives. Mainframes

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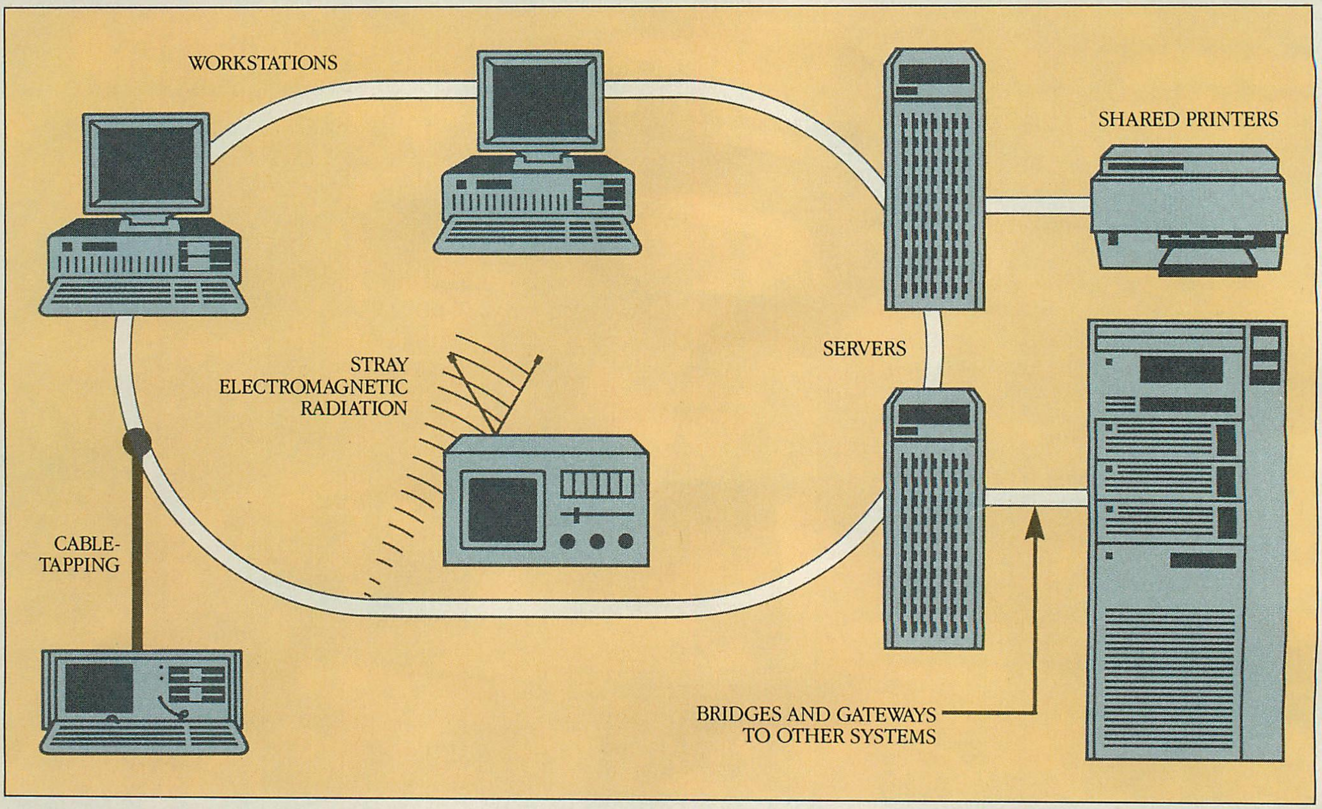
FIGURE 1: ***Physical LAN Security Threats***



The distributed nature of a LAN means that information can be obtained at many points in the network. The LAN can be accessed through workstations and, on some networks, the server itself. Bridges and gateways also pose a security threat on both sides of the connection and require careful scrutiny. Access to the LAN cable is another risk. Sophisticated eavesdroppers can use LAN analyzers or special electromagnetic receivers to tap the signal that is being passed on the cable.

and minicomputers, on the other hand, can be kept in locked rooms and attended by operators.

For maximum performance in a LAN, functions are distributed between the workstation and the server, but security may dictate a different division of labor. For example, security checks at the workstation, especially under DOS, can easily be defeated by patching the security checking code.

Improving LAN security and reducing exposure entail costs that must be weighed against the risks. Just how valuable is the information and what is the likelihood of an attempted breach? Does the information have competitive value? Would its disclosure trigger legal action or violate personal privacy? Obviously, the more attractive that the information is to an intruder and the greater the cost of a breach, the more justification there is for the security expenditures.

PHYSICAL RISKS

Some physical points of vulnerability are shown in figure 1. Sophisticated software and hardware security measures do not eliminate the need for good physical security at the servers, the workstations, and the cable.

Security on the server is particularly critical if the server runs DOS and its files are stored in standard DOS format. An intruder could access files by booting standard DOS without even needing file-server software. This particular exposure is exhibited by the IBM PC Network program.

For any LAN operating system, the best policy is to lock the server in a room with limited access. Where this is impossible, the PS/2 Models 50, 60, and 80 offer a solution—a *server password* that allows the machine to be booted, but prevents use of the keyboard until the password is typed in.

Workstations are also at risk if they are left unattended. To protect against users leaving logged-in workstations, a secure network would require revalidation of a connection after a period of inactivity. Ideally, users should log off the network or lock up the PC whenever they leave it. In most networks, this requires a significant amount of effort to log back onto the network and restore the printer and the drive mappings previously set.

There are less cumbersome (and more enforceable) solutions: the PS/2 Models 50, 60, and 80 have a program named KP.COM on the reference diskette that can be used to disable the keyboard while the user is away from the computer. In this way, the user can remain logged in to any servers or hosts without threatening security. The risk of physical security breaches also can be reduced by giving two user IDs to system managers: one low-privilege ID for routine daily work and an omnipotent ID for broad access.

Printers connected to the LAN also can be a security threat. Sensitive information should not be printed on unattended printers where it might be seen (or even taken for copying) by any unauthorized personnel.

Access to the LAN cable is another physical risk. Snooping devices for IBM-Token Ring and Ethernet-type networks are now available, although at five-digit prices (see "Analyzing Network Traffic," J. Scott Haugdahl, October 1987, p. 48). This risk can be significantly reduced by the use of fiber-optic media, which increases hardware, media, and installation costs and makes

network additions and cabling changes more difficult. Reducing access to the actual wire is a less expensive, but imperfect, solution.

In addition, all electronic devices emit electromagnetic signals produced by electricity. Sensitive snooping devices can pick up these signals from a workstation, whether or not it is on a LAN, and intercept the data flow.

If the workstation is shielded, usually with lead, electrical emissions can be reduced to an undetectable level. The 10-year-old federal Tempest standard specifies the emission level acceptable for secure applications.

Manufacturers such as IBM, Digital Equipment Corporation, and Wang have been offering Tempest-certified equipment for several years. Such certification can double a product's cost, and the certification process can take up to three months. Government agencies are the largest buyers of Tempest-certified products. However, interest in the private sector has risen as concerns grow about data security, particularly with regard to competitive data.

The Tempest standard also can be applied to LANs; it requires wire shielding to reduce spurious emissions. Because this is expensive, encryption of data transmitted on a network cable might be more practical.

File encryption with decryption at the user workstation adds security to both the file server and the transmission medium. The decryption key can be a string of characters known only to the user. The data are secure from other stations, illegal taps, and interception of spurious electromagnetic radiation. However, encryption is not a panacea; it adds overhead, especially because it is often handled in the software. Data can still be lost if the encryption key is forgotten or the data file is maliciously or accidentally deleted. Because the encryption must be reversed at the workstation, it does not eliminate the need that exists for Tempest workstations.

IDEAL SECURITY

The security features of the operating system are crucial to overall network security. The attributes of the ideal network security system described here are not patterned after any existing network, although they do borrow heavily from minicomputer and mainframe operating systems.

Giving the password. Access to a LAN should require the user to type a personal identification and password. This log-on, or user, ID is commonly based on the user's name. Some networks name machines or nodes instead of users, assuming that the same people use the same workstations every day. However, this is seldom the case; no matter how large the office, workstations are occasionally shared.

The user ID literally is the key to network access. Every password should have a minimum of six or seven characters. One- or two-letter passwords can be guessed easily by trial and error. Brute-force guessing can be made more difficult by distinguishing between uppercase and lowercase, by using special characters, and by suspending the ID after a certain number of incorrect passwords have been tried. The count of bad passwords should reset itself periodically, so that the cumulative effect of normal typos does not suspend an ID.

Sensitive snooping devices can pick up signals from a workstation, whether or not it is connected to a LAN, and intercept the data flow.

The password-encoding scheme should work only one-way; the LAN manager or anyone else should be allowed only to change a password, not look it up. When the manager changes an ID, the ID's owner should be required to change the password when next signing on the LAN. An audit trail should keep track of the ID of the user who actually changed the password.

Passwords should be typed in every time they are needed. A network that allows the password to be piped from a batch file or log-in script exposes that password to disclosure. This danger also applies to passwords for mainframes and minicomputers connected through gateways to the LAN. PCs often use scripts to automate data retrieval from a mainframe by logging in and querying programs. If the mainframe password is part of the script, any security provided by the mainframe is effectively nullified. In this case, the PC must provide security by controlling physical access or by encryption.

Passwords also should be changed periodically. A software-enforced policy for changing passwords guarantees that compromised passwords are valid for only a short period. The facility for changing the password should be easy to use. The password should not be echoed as it is typed. Requiring the user to reenter the same string of characters to verify the new password reduces the number of requests that are made to the network manager to change a password because the user has inadvertently mistyped it.

Passwords should be validated in code executed on the server. In DOS, a clever intruder could bypass workstation validation by modifying some code to branch around the verification step.

Policy should exclude names of spouses, pets, or children for passwords. System-assigned random character and number sequences are best, but could irritate the user and require the manager to change more passwords. Policy also should require everyone to have and use a personal ID and password. This should apply even when using another's workstation, in order to trace the access and activity at a workstation to an individual.

A complete security scheme should allow powerful IDs to be restricted to the actual workstations that belong to the ID's owner. This protects against an outsider's observing the owner's keystrokes and attempting to use that ID at his own station. Access also should be selectable from a gateway or remote modem connection so that only workstations actually on the file server's immediate network can access the file server.

Obtaining permission. A complete security system treats volumes, directories, and files as hierarchical entities. The owner of each entity can limit access to specific users, multiple users, predefined groups of users, or can grant access to all users. Each entity should have a complete set of *permissions*, or security attributes, not only to control access but also to aid in system management. For files, these permissions should include create, delete, open, read, write, and execute. For directories, they should control the persons who can search the directories as well as those who are able to manage the subdirectories.

User IDs also should have general permissions that apply across the board to all entities on a server. For example, one user may need only to read the files on a server. If the user's ID is limited to read-only, the network manager can be sure that the user will not be adding any files. This not only tightens security but also increases performance and the response time.

Permissions should be hierarchical and presume the least amount of access. For example, a volume might be fully open to an entire work group. However, if the permission assigned to a directory within that volume restricts access to one specific ID, files in the directory and any subdirectories are restricted to that permission. Conversely, if more permissions are added at a lower level, these would propagate to the entities beneath that level. If no permission applies, no access is given.

Sophisticated mainframe security systems such as the Cambridge System Group's Access Control Facility (ACF2) limit access further by the day of the week, date, time, program name opening the file, and directory from which the program is executed. An expiration date can be placed on permissions.

Time and date are useful for denying access while another work-group or maintenance application needs access, or if access is allowed only under personal supervision. Control by program name ensures that only particular applications can access a file or directory. For example, a spreadsheet directory might be readable by Lotus 1-2-3, but not by the COPY command. An expiration date is useful to keep the database of permissions clean, particularly within the context of an environment of transient users.

Securing the file server. To be effective, a file-server security system must be easy to use. It can be operated through menus, commands, and application program interfaces (APIs), with all functions available to each means of access. Menus should allow the obvious operations through intuition, yet contain a complete set of functions for the more experienced user. All operations also must be accessible from commands, so that batch files can automate routine operations. Finally, applications such as database managers should be able to perform security operations so that they can be integrated into the LAN; this requires an API.

A facility should print and test permissions, particularly if they depend on factors such as time of day, date, or application program name. A comment field in the stored permissions is useful for documenting the reasons for the granting of permissions.

Some security systems go to great pains to protect user files, only to put printer spool files in a common location that everyone can access. Spool files frequently contain the images of confidential reports and should be placed in a user's private file area or in a directory accessible only to the print server and spooler.

SECURE MANAGEMENT

LANs, like any shared resource in an organization, need some management. The more resources are shared, the more management is required. In large organizations, two persons often supervise the resources: one from the work group and another from the support department. This duplication can increase risk exposure; a division of responsibility, with appropriate restrictions, can improve security.

The work-group manager should not be able to access all files automatically or override access rules, but should be allowed to add IDs and change passwords (if they are stored in a one-way encoding scheme). This manager should be allowed to back-up the entire file server but not to access its contents without permission. Any restore operation should retain the security features of the original data.

Some security systems go to great pains to protect user files, only to put printer spool files in a common location everyone can access.

In addition, the work-group manager should receive an audit report of all extraordinary accesses and password changes made in the support department. Specific permissions that allow access to data should be maintained by the data owners or installed by the support-department manager with written authority by the owner.

The support-department manager should be allowed to perform all the functions of the work-group manager, and also specify special access rules for emergency access when the owner is not available. These special rules should create access records that can be audited by the work-group manager, the data owner, or an internal or external auditor. The support manager should receive an audit report of any password changes made by the work-group manager, as well as a list of any extraordinary accesses. Although these restrictions limit the managers and make some tasks longer, they help create a more secure system.

LAN managers do not need automatic access to all files on the file server. Network file servers will never be fully utilized until users are confident that their data are secure even from the LAN manager.

Mainframe security packages, such as ACF2, long ago rejected the presumption that the system manager should have automatic access to everything. In these packages, all files that are accessed because of the manager's privilege (rather than by explicit permissions) are logged in a special audit trail. The manager must grant himself special permission to access a file outside normal permissions. File owners or auditors can run reports showing all accesses by the manager.

Even a trusted LAN manager can unwittingly cause damage to the network, particularly if a highly privileged account is used for routine work. A significant danger is posed by the *trojan-horse* program, which tricks a user with high privilege into performing work for a lower-privilege account.

Many installations invite this type of trickery by creating a writable directory on the server that is included in each user's search path. The directory is intended to contain utility programs that local users find worthwhile for doing their work. An unprivileged user could place a program in this directory that detects when the directory is being used by a high-privilege account and then secretly issues commands. For example, the program might change permissions on files or increase the privilege of the user's account.

Safeguards against a trojan-horse program start with firm control over the contents of program directories and must include a review and approval process for locally written programs. For security and maintenance, source code should be examined and retained by the system manager.

Despite the best efforts to maintain security, occasional lapses will occur. Many are unintentional or accidental changes to security that go undetected because they do not affect normal LAN operation. Others are painfully obvious: failure of the system, a headline in the local newspaper revealing sensitive information, or a lawsuit. In all of these cases, *audit controls* should determine who had access to the information, who used or changed the information, and when access was made.

Audit controls can be classified as follows: *historical*, *static*, and *dynamic*.

The historical record, or audit trail, details previous activity, including

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ARCHITECTURE If the micro world were not so varied, QNX would not be so successful. After all, it is the operating system which enhances or limits the potential capabilities of applications. QNX owes its success (over 30,000 systems sold since 1982) to the tremendous power and flexibility provided by its modular architecture.

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MULTI-USER OS/2 is multi-tasking but NOT multi-user. For OS/2, this inherent deficiency is a serious handicap for terminal and remote access. QNX is both multi-tasking AND multi-user, allowing up to 16 terminals and modems to connect to any computer.

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important events, the user ID, time, and type of event. However, the audit trail is akin to closing the stable door after the horse has escaped—the damage can be traced, but it cannot always be undone.

Static audit information, on the other hand, can avert security problems. These reports detail the security levels of user IDs, files, devices, and other resources on the LAN. These data can be examined for incorrect or suspicious settings and corrected before a problem occurs. To ensure that a security breach did not occur, the audit trail also should be checked whenever a security anomaly is found.

The dynamic audit control pictures the LAN as it operates; it includes the names of logged-in users and the names and access modes of open files. One resourceful application for the dynamic audit control is to prove compliance with software-licensing restrictions. A site with a 20-user LAN might be able to buy just five licenses for a software package if the company can verify that no more than five users simultaneously run the program. Of course, many suppliers of LAN software provide a built-in mechanism in order to guarantee the compliance of the users with the software license.

SECURING DIRECTORIES

How well do present LAN operating systems match these security needs? For an answer, two popular LAN operating systems are examined—Novell NetWare and the IBM PC LAN.

NetWare includes most of the structure needed for complete security but does not realize the full potential of its structure. The recently announced version 2.1 of NetWare promises many improvements, but was not available for review (for more details, see the sidebar below, "NetWare 2.1 More Security-Conscious").

All of the permission types of the ideal security system are included in NetWare, although execute-only permission is provided through a separate table, which is maintained by a program that is in the developer's toolkit.

In NetWare, the permissions assigned to an individual ID or group are

NETWARE 2.1 MORE SECURITY-CONSCIOUS

Novell announced NetWare 2.1 as this article went to press. The new version addresses many of the deficiencies of user ID control in version 2.0a and earlier. Version 2.1 will be available first in Software Fault Tolerant NetWare in December 1987; version 2.1 for standard NetWare will be available first quarter 1988.

The new security features of Netware 2.1 are listed below.

Limited concurrent connections. The number of simultaneous connections an ID can have is limited; only one session by ID's with access to critical data should and could possibly constitute a requirement.

Half-hour security revalidations. Every half-hour, NetWare checks each workstation connection to ensure that the connection is still valid. This prevents a lengthy illegal session by an intruder who physically disconnects a session in progress and connects a different workstation in its place. It also forces those users who have disabled accounts off the network within 30 minutes of the suspension.

Disabled accounts. Accounts can be disabled, as opposed to deleted, to suspend access as a response to a security problem.

Six password security improvements. Required passwords; required minimum password length; forced periodic password changes; one-way encoding of passwords with a supervisor password-changing mechanism, such as the one described in the ideal network in this article; required unique new password (2.1 remembers the eight last passwords and can be set to prohibit their reuse); optional feature, make a password changeable only by the supervisor.

User ID expiration dates. This feature, and passwords changeable only by the supervisor, are good for guest and temporary ID. Novell begins to call user IDs *accounts*, perhaps because of the new accounting features described below.

Log-in time restrictions. An account can be set to permit log-ins only during certain time periods.

Station restrictions. Accounts can be set to log in only from one node.

Intruder detection and lockout. The supervisor can specify the number of incorrect passwords that can be presented during a particular time interval. If this limit is exceeded, the account is suspended for a set amount of time. In addition, an audit record is generated.

The supervisor still has complete, unaudited access to all files, and the supervisor account is exempt from any restrictions that might jeopardize the supervisor's function. However, several new features improve auditing capability. The following restrictions listed below can be applied to the supervisor account.

Log-in time restrictions. This facility must be exercised with all due care; this is because restricted access might prevent the supervisor from being able to correct a problem occurring outside of the regular hours.

Station restrictions. None.

Periodic password-change reminders. Password changes are not really forced, because the supervisor has an unlimited grace period in which to use the old password.

Intruder detection. A suspended supervisor account needs to be reset from the console.

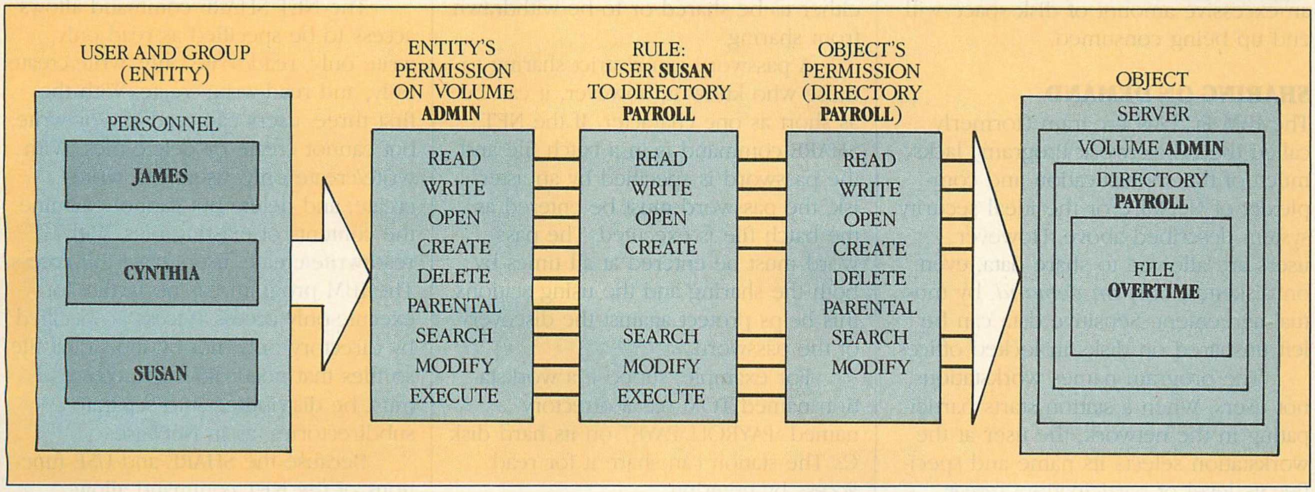
NetWare 2.1 also includes several management improvements and, for the first time, accounting functions that can be activated at the discretion of the supervisor. An installation can choose to charge for services with a declining dollar balance; log-ins are inhibited when a balance runs negative. An audit record is written of each log-in and log-out. Of great management value is a mechanism to control each account's disk space.

Any file operation that would cause the disk space limit to be exceeded results in a message "OUT OF DISK SPACE." However, a measure this severe could force a user to abort an application, and to lose data, depending on the application's method of storing data. A more passive approach, such as checking at log-in time and allowing only a limited number of log-ins until the user complies with the limit, could reduce this risk and inconvenience; however, it is not available.

The improvements in 2.1 address most of the user ID-related security deficiencies in NetWare, but leave the supervisor unchecked. Only applications that have an encryption mechanism employing a key provided by the end user limits access by the supervisor. The new NetWare has no encryption capability in the file server. Nonetheless, Novell's NetWare is still well ahead of its major competitors in access security, particularly in protecting user ID and password.

—*Art Krumrey*

FIGURE 2: ***NetWare Access Control***



In NetWare, access to a directory is determined by a combination of the user's trustee rights and the limitations imposed by the directory's maximum-rights mask. In this example, user SUSAN has very restricted access, but the group PERSONNEL has more liberal access. These privileges are limited by the rights mask for PAYROLL; here, the delete privilege is removed.

called *trustee's rights*. In addition, each directory has a *maximum-rights mask*. Access to the directory is not granted, regardless of the trustee's rights, unless the maximum-rights mask allows access. The effect of NetWare's security scheme is shown in figure 2.

Permissions in a particular directory propagate to its subdirectories, unless the rights are redefined at a lower level. Access is not allowed unless rights are explicitly granted; this does not apply to the *supervisor*, who has rights to all data.

Users have rights to entire directories—the lone facility for controlling access to individual files is the read-only flag defined by DOS. Because NetWare has no facility for restricting access to specific files, the system manager must install parts of the application software in different subdirectories to ensure thorough security. For example, a secure installation for a word-processing application program might divide the files into subdirectories, including the following:

- Open access to a main program in a search directory that specifies the locations of other files. This program would be marked execute-only so that it could be run but not copied.
- Overlay and configuration files in a second directory that allow read and open access, except for personal configuration files of shared software.
- Work and spill files in a third directory that allow read, open, create, delete, and write access, or in the same directory as user files.
- User document files in a fourth directory to which the user has full access.

This separation of files into subdirectories is good management and expedient if more than one person uses the software simultaneously. However, individual file security would simplify the process. Some application programs also may not let these files be placed in separate directories.

NetWare has a convenient way to give several users the same rights. The manager can designate that one user's security is equivalent to another's, duplicating the first user's rights. A user's total trustee rights are the rights assigned explicitly, plus the rights of others (individuals and groups) to whom security equivalence has been granted.

OPTIONAL AUDITING

Despite the importance of auditing to security, NetWare does not have a built-in audit facility. However, two third-party add-on security products are LANTight from Blue Lance and LANTrail from LAN Services, Inc. Only the general capabilities of these products are summarized; an upcoming article includes a complete review.

LANTight tracks all network log-ins and log-outs and selectively tracks file accesses and actions. It requires each network user to start a RAM-resident program (called RAM) before accessing the network. This program can be relocated to a hidden area that cannot be removed by resident memory managers such as Persoft's Referee (see Product Watch, this issue, p. 159). Starting the resident program is best done as part of the system log-in script to ensure that the user does not get onto the network without RAM in place.

RAM intercepts all open, close, delete, write, rename, create, and subdirectory operations, as well as all network log-ins and log-outs. It can monitor even local file operations. Logging records are written only if the file or directory is listed in LANTight's filter. In addition, LANTight can selectively log particular DOS function calls, such as **open**; and its filter specification supports DOS wild cards.

LANTight's filter capability is both a blessing and a curse. It allows the manager to reduce overhead by monitoring only critical files, but does not monitor access of other files. The user could easily copy files to an unmonitored directory.

The second add-on security product—LANTrail—intercepts the same DOS calls as LANTight does. It also tracks network log-ins and log-outs, security rights changes, and program executions. However, it has no filter capability; all accesses are logged.

LANTrail loads as a resident program in a user's AUTOEXEC.BAT file; another program in the system log-in script ensures that LANTrail is already loaded and also controls the number of simultaneous users who are logged on with that particular user ID.

This product provides a rich set of reports that has more detail than an audit trail reveals. These reports include a display of the user's log-in script and current rights, a directory access report, and an executed programs report. Unfortunately, the reports can be started only from a menu; a batch file cannot be used to produce periodic reports. In addition, the large

volume of records generated must be compressed periodically by a utility, or an excessive amount of disk space will end up being consumed.

SHARING ON DEMAND

The IBM PC LAN Program (formerly called the PC Network Program) lacks much of the sophistication and complexity of NetWare or the ideal security system described above. However, users are allowed to share data, even on diskettes, only *on demand*, by mutual agreement. Sensitive data can be left unshared on disks in locked offices.

The program names workstations, not users. When a station starts participating in the network, the user at the workstation selects its name and specifies its level of participation: *server*, *messenger*, *receiver*, or *redirector*. A workstation with a server level must share everything with all levels, including the redirector. The messenger and receiver levels allow increasing degrees of message handling but do not affect sharing or security.

A user does not sign on to the network because names are not stored centrally. Passwords are not required for basic access, but are required to use and share entities. The heart of the data-sharing capability is the NET SHARE command, which allows entire disks, specific directories, and printers either to be shared or to be withdrawn from sharing.

A password can restrict sharing to those who know it; however, it can be as short as one character. If the NET SHARE command is in a batch file and the password is specified by an asterisk, the password must be entered as the batch file is executed. The password must be entered at all times by both the sharing and the using stations; this helps protect against the discovery of the password.

For example, suppose a workstation named TOM has a directory named \PAYROLL\PAY87 on its hard disk C:. The station can share it for read access by entering

```
NET SHARE PAYDIR
  = C:\PAYROLL\PAY87 * /R
```

PAYDIR is called a *shortname*; it allows other stations to access the directory without knowing its exact location on the server. The * causes a prompt for a password. The following command:

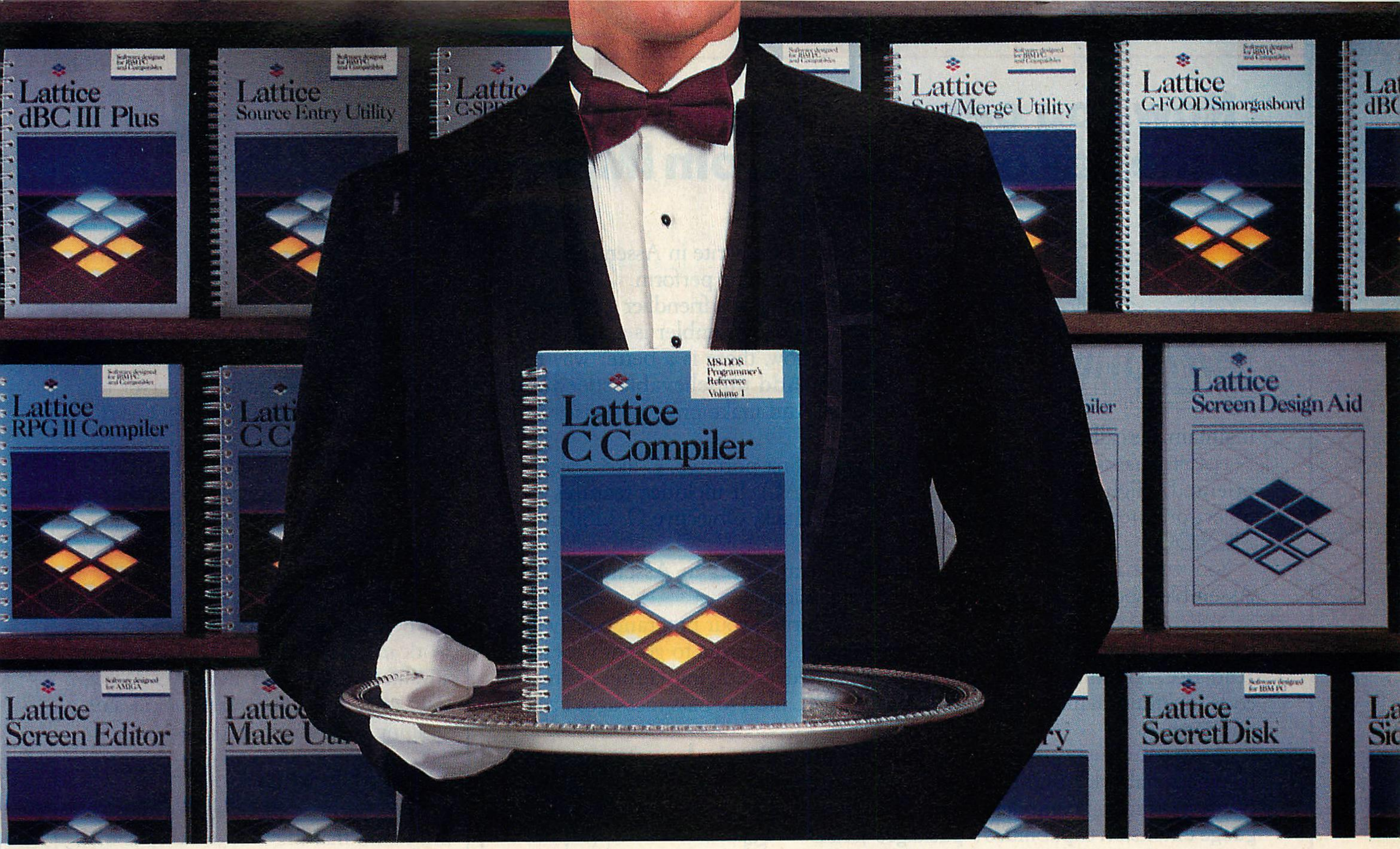
```
NET USE D: \\TOM\PAYDIR *
```

would allow access by any user on the network who knows the password to PAYDIR on Tom's workstation. The directory would appear as virtual drive D: on the user's station.

The NET SHARE command allows access to be specified as read only, write only, read/write only, write/create only, and read/write/create. With the first three, users can read and/or write, but cannot create or delete files. With write/create only, users can write, create, and delete but cannot examine the contents of existing files. With read/write/create, users have full access. The IBM program has no facility for execute-only access. Access is specified by directory only, not by individual file, so files that need different accesses must be distributed into separate subdirectories, as in NetWare.

Because the SHARE and USE functions of the NET command allow shared objects to be named, security is enhanced; the user needs to know only the shared object's name and password, not the exact directory being shared. Unfortunately, the user also needs to know the name of the computer containing the shared data.

One disadvantage of placing individual passwords on resources is that every user must remember and type many passwords. The temptation is great to place the passwords in a batch file or to omit passwords altogether. In



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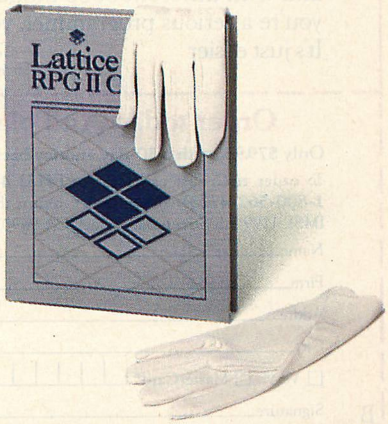

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addition, if a security breach is suspected, all of the passwords must be changed, and all of the users of the resource must be notified.

Sharing is specified through the NET command, which has both command-line and menu versions. Both versions offer all operands; the menu is handy for new users and the command line is useful for batch files. Two commands can be issued at the server to keep track of sharing: NET FILE and NET SHARE. The NET FILE command shows all open files and record locks in the server, and allows the server to close the file. The NET SHARE command displays all objects that the server is currently sharing.

PC LAN provides no audit capability. Because it is decentralized, no network manager has access to all data, an advantage over other networks. Decentralization does, however, complicate auditing, operation, and maintenance.

A SECURE FUTURE

Strong concerns about security are an indication that the LAN industry is maturing, and that LANs are being used or considered for storing and processing of valuable information.

Senior management is likely to become more demanding of the network manager as concerns increase about the privacy and security of data. The trend to store—or at least download—sensitive data to PCs or PC LANs, has become a cause for concern for the PC network manager.

However, even the best LAN operating systems need to be improved before they can rival the security found on some minicomputers and mainframes. Because DOS is an open, vulnerable platform, it is difficult to build a truly secure network from DOS workstations. Presumably, OS/2 will help relieve this problem. In addition, technical advances, such as low-cost fiber-optic cable and data-encryption chips, eventually could offer economical improvements in LAN security.

Yet technology offers only assistance, not answers. Before an operating environment can be secure, the organization itself must make a commitment. Potential security risks must be assessed, rules for protecting crucial information enforced, and periodic inspections conducted to ensure that rules are being followed.

Art Krumrey is director of academic computing services at Loyola University of Chicago. He has a master's degree in computer science from Northwestern University.

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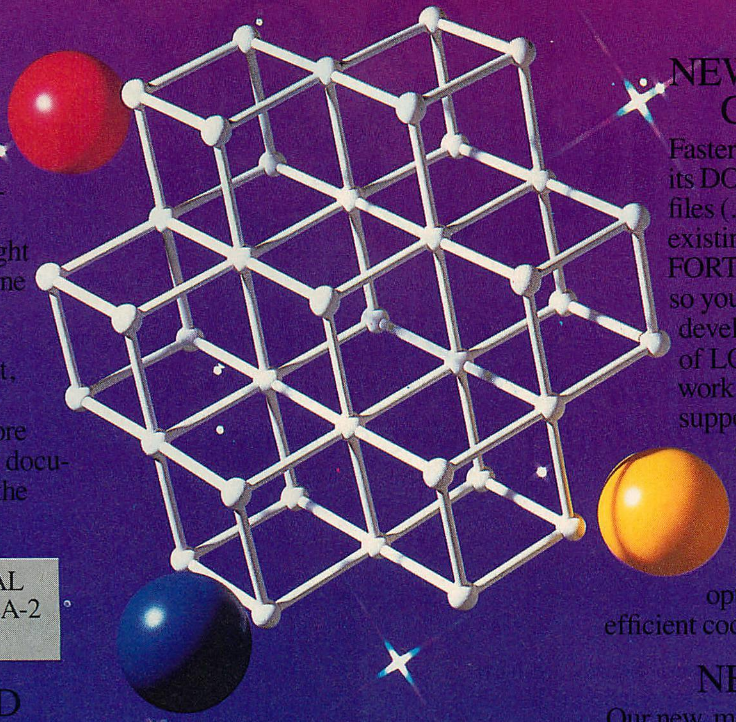

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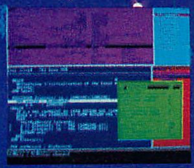

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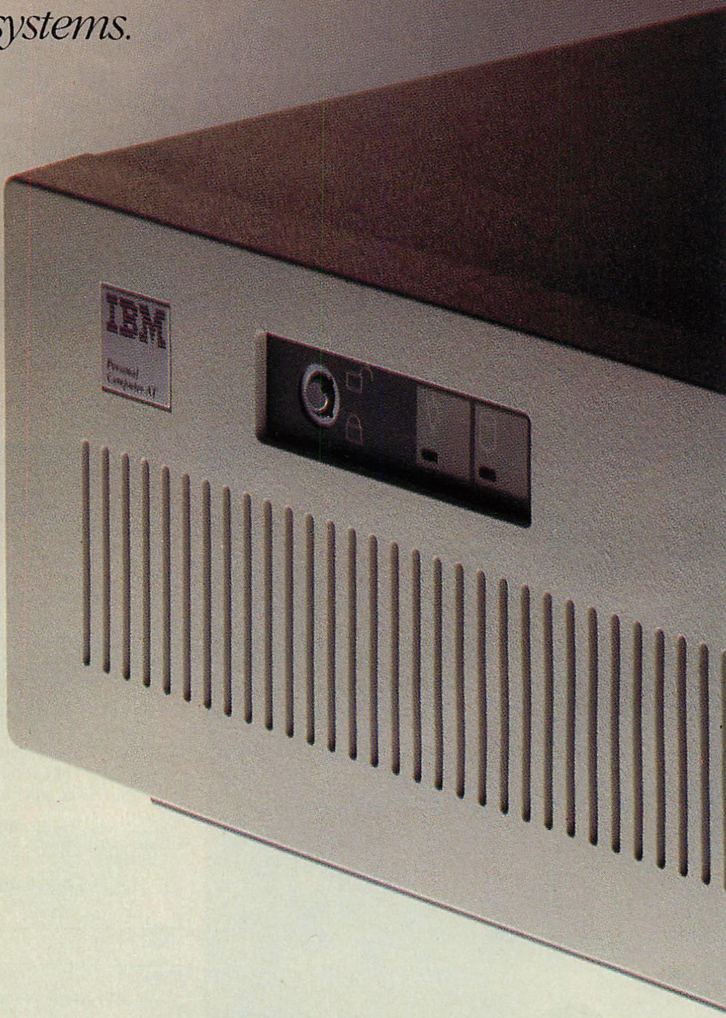
CIRCLE NO. 229 ON READER SERVICE CARD

Accelerating to the 386

New 386 accelerator boards add punch to 286-based systems, without the knockout price. They prove an excellent alternative to replacing complete systems.

KENT QUIRK



Dynamic new 386 accelerator boards are hardware alternatives for those wanting enhanced capabilities of the 80386 microprocessor without incurring the expense of replacing their total hardware setup. These boards deliver 80386 features to existing 80286-based systems. They provide accelerated performance, increased memory space, hardware support for virtual memory, 8086 emulation in protected mode, including protected I/O, and the benefit of multitasking (see "Upward to the 80386," Caldwell Crosswy and Mike Perez, February 1987, p. 50).

With the introduction of the 386 more than a year ago, software developers have wasted no time marketing new applications, operating systems, and applications managers that fully exploit 386 strengths (see "386 Operating Environments," Ed McNierney, this issue, p. 60). The number of such programs is expected to shoot up dramatically in the next few years.

Similarly, 386-based machines themselves are becoming more widely available. Because 286-based systems, however, still make up the majority of PC systems in use, 386 accelerator boards offer a less-expensive choice to many for tapping 386 features. The four add-in boards reviewed are American Computer and Peripheral's 386 Turbo, Applied Reasoning Corporation's (ARC) PC-ELEVATOR 386, Intel Corporation's Inboard 386/AT, and Orchid Technology's Jet 386.

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Such accelerator cards are ideal for users running lengthy or time-critical DOS applications, such as CAD/CAM or large databases, who seek the fastest microprocessor available but do not want to discard their current hardware. Users see the 386 as the undeniable future of microcomputing, and accelerator boards as the minimum-cost investment in that future.

What is the major tradeoff of this minimum-cost approach? In this case, it is compatibility. A computer with a replacement CPU is not as reliable in all applications as one designed around its microprocessor. The accelerator boards tested had some compatibility problems but, fortunately, most were not serious enough to preclude doing useful work on the converted system.

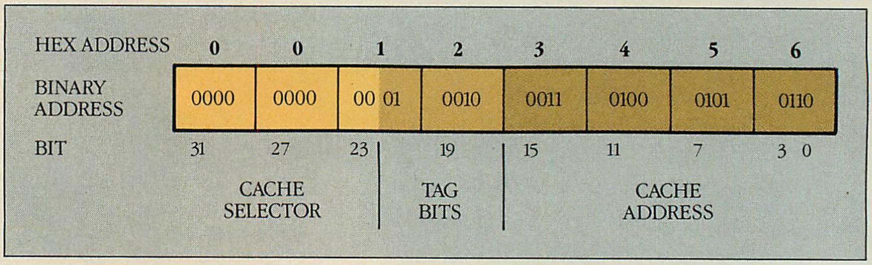
Serious design tradeoffs must be made when designing a 386 accelrator board for use on an AT host. In some cases, a board decreases raw processing power. Design of the memory subsystem is a crucial determinant of the performance of any 386 system, but it becomes the most crucial single factor when interfacing to an existing bus designed for a microprocessor with lower performance.

The 386 typically runs at a clock rate of 16 MHz (twice the speed of a typical AT), although parts that run at 20 MHz are now available. However, demands on memory are not as rigorous as these clock rates suggest; to reach their full performance, the cards do not require memory with twice the speed of an equivalent 286 system.

The 386 setup and hold times are shorter than those of its predecessors, meaning that an address stabilizes on the bus earlier in a transfer cycle, giving the memory more time to respond. Nonetheless the memory subsystem must respond to read requests within 75 nanoseconds (ns) or the CPU will add one or more wait states to the minimum bus cycle of two clocks. At 16 MHz, each wait state increases the bus cycle (two clock ticks at minimum) by 62.5 ns; according to Intel, going from zero to one wait state reduces performance by 19 percent.

To optimize memory performance for back-to-back memory accesses, the 386 can put the address of the second access on the bus in the middle of the first bus cycle, after the memory system latches the first address. This is called *address pipelining*; it provides three clock cycles from the time the address appears until the end of the bus cycle, allowing slower memory to respond without inserting any wait states. The wait state is overlapped with the second half of the preceding bus cycle. Intel claims that pipelining can improve performance by 5 to 10 percent.

FIGURE 1: ***Direct-mapped Cache Addressing***



Caching hardware divides each physical address into three fields. The selector field determines if the address can be cached; the tag bits, if it has been cached. If so, data are read from the cache location given by the cache address field.

On a 16-MHz 386, a REP STOS instruction moving 32-bit data into zero wait-state RAM can fill memory at a rate of 4 bytes in every 5 clocks, which is 12.8MB/second. However, if the CPU is forced to go to an AT's system board RAM (typically 16-bit, one wait state), it takes 11 clocks to move the same 4 bytes, for a transfer rate of 5.8MB/second. If the access is over the system bus to video RAM (typically 8-bits wide, and possibly 10 or more wait states), the penalty is even greater. Thus, any 386 system that relies on the system bus for memory access will fall far short of the CPU's ultimate capabilities.

Not only does the 386 require fast memory, but it usually requires lots of it. Its advanced capabilities, such as memory mapping, multitasking and execution in protected and virtual modes, are practical only if implemented in a RAM space of several megabytes. Fast RAM in these amounts can be rather expensive.

CACHE MEMORY

Some manufacturers of complete 386 systems and accelerator boards implement a high-speed memory cache to improve RAM performance without paying the price of a large, fast memory subsystem. Caching can be used in any kind of system, even one designed from the outset for the 386, but it is especially useful when a fast microprocessor is coupled with a system that is already configured with large amounts of relatively slow memory.

In a cache, all data remain in main (slow) memory and the cache keeps a copy of a subset of them. If requested data is found in the cache (a *cache hit*), then a net gain in speed is achieved because accessing main memory is unnecessary. The percentage of accesses that are hits, called the hit rate, is dependent not only on the cache design, but also the program's characteristics. The cache normally is filled as accesses are attempted; at first, of course, all accesses are misses. Most software has a locality of reference in that programs use the same memory areas repeatedly. With time, the hit rate goes up because frequently used data are found in the cache.

Ideally, a cache that can contain N items would hold the N most used items. One implementation for this ideal is to allow a cache location to hold data from any location in main memory. The cache then contains data and addressing information relating them to their location in the main address space. Each memory access would require a search through all of the address entries in the cache to see if any of them match; this is called associative memory, or content-addressable memory. However, depending on the complexity and speed of the address comparison logic, this approach is either too slow or too expensive. It ultimately defeats the reason for having a cache in the first place.

Another alternative is direct-mapped cache. A cache entry can contain one of a small number of memory items; a tag RAM contains enough information to distinguish the possibilities. For example, a cache might be implemented with 64KB of high-speed static RAM, and an additional 64K-by-6-bits of tag RAM. Each location in the tag RAM can take on 2^6 or 64 values, indicating that each cache location can hold data from one of 64 locations in main memory. The cache therefore covers the lower 4MB (64 times 64KB) of main memory.

To understand cache operation, consider a read from physical address 00123456H. At each memory access, the cache subsystem splits the 32-bit physical address into three fields as shown

in figure 1. If any of the high-order 10 bits are nonzero, the address is above the first 4MB and thus outside possible cache memory; the reference is passed directly to the main memory system. Otherwise, the low-order 16 bits of the address (3456H) are used to access the tag RAM, and the contents compared with bits 16 through 21 of the address (12H). If they match, then the required data are available at location 3456H of the cache. If not, data are read from main memory and written to location 3456H of the cache; the middle 6 bits of the address (12H) are written to location 3456H of the tag RAM. A subsequent reference to address 00123456H results in a cache hit.

Although most of the events described above happen in parallel, caching has its penalties because it takes a finite amount of time to determine that a miss has occurred. Access to main memory is then delayed by at least one clock cycle, resulting in one additional wait state. The hope is that the hit ratio will become high enough that a net improvement in access time is then realized, but poorly localized software (such as the SORT program used in the benchmark tests) can cause a net loss in performance.

When data are written to memory, both the cache and main memory must be updated to avoid presence of stale data. The most common strategy for updating is the *write-through* method, in which every write is duplicated to both main memory and cache. With this scheme, write cycles gain no benefit from caching, but also incur no penalty, because both writes start at the same time and proceed in parallel.

Cache performance of a specific program depends on the relative speeds of cache memory and system memory, on the size of the cache, and on its implementation. The bigger the cache, the better its hit rate, but, unfortunately, the greater it costs.

SYSTEM INTERFACE

A card that connects to the system bus only through an expansion slot cannot directly access the system board circuitry, including the direct memory access (DMA) controller, the system board RAM, and the system timers. Two basic approaches exist for integrating a second processor into a system: as an *emulator* or as a *coprocessor*.

In the emulator design, the new CPU replaces the original 286 processor. The accelerator board connects to the system board with a cable that plugs into the vacated 286 socket. The processor on the add-in card then emulates the action of the 286, addressing chips on the system board in the same way as did the old CPU. In a variation of this design, the original processor is plugged into a socket on the accelerator board, allowing the user to revert to the 286 in the event of compatibility difficulties. At any one time, only one microprocessor is active, the other one is disabled.

One problem with the emulator's need to plug into the CPU socket on the system board is that the 286 is sold in three different packages. PGA (pin grid array) is the most expensive and is used by IBM and Compaq. LCC (leadless chip carrier, also known as JEDEC) is used by Tandy and some compatibles. PLCC (plastic LCC) is used by early PC's Limited machines and compatibles. When buying a 386 accelerator board, users must order a PGA or LCC connecting cable. None of the four accelerators reviewed has connectors for PLCC sockets.

The use of caching has its penalties because it takes a finite amount of time to determine that a miss has, in fact, occurred.

In the coprocessor design, the accelerator board connects to the system bus alone. Resident hardware and software on the board trap certain I/O and memory requests and pass them on by means of hardware interrupts to the original CPU, which remains on the system board. The CPU performs the request and sends the results to the 386 through an I/O port; in the meantime, the 386 does other tasks. In effect, two computers run at the same time within the same case, sharing the same peripherals and some parts of system memory. Compatibility problems can be both better and worse than with an emulator. Although it is more difficult to get two processors to work together, the accelerator board can be totally disabled by software or hardware switches, effectively returning the system to its original state with the native CPU on the system board.

Most users who are interested in accelerator cards also are interested in math coprocessors because floating-point performance improves by a factor of three to five with an 80287 variety present in a system. The 80387 math coprocessor is roughly three times faster than a 287, but costs about $500 more. An adapter for using a 287 in a 387 socket is fairly simple to create, but the reverse is impossible. Therefore, the most flexible accelerator design provides a 387 socket and a choice of either that coprocessor or a 287 on an adapter daughterboard.

REVIEW PROCEDURES

The 386 accelerator boards were tested using similar hardware and software as in *PC Tech Journal*'s compatibility and performance series of evaluations of complete 286 and 386 systems. The machine used for testing was an older IBM PC/AT originally designed for 6 MHz, but upgraded with a new crystal to 8 MHz. Unlike later 6-MHz ATs, the machine did not have the speed-cop ROM that shuts down the system if speed increase is detected.

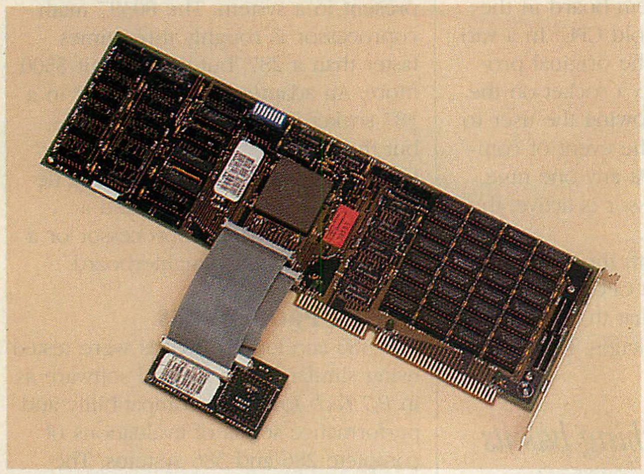
Borland International's SideKick, SuperKey, and Turbo Lightning were used to test the accelerator boards. These programs, being memory-resident and fairly hardware-specific, push the limits of software compatibility. Living Videotext's Ready! and Intel's QUIKMEM2 RAM Disk test the boards' ability to deal with expanded memory, such as that found on the Intel Above Board. IBM's VDISK tests the CPU's ability to enter protected mode and access extended memory.

Boards were tested also with 386-specific software, including The Software Link's PC-MOS/386 and Digital Research, Inc.'s Concurrent DOS 386 (both operating systems), Phar Lap's RUN386, and an early release of Microsoft Windows/386. In addition, each was tested with Quarterdeck's DESQview, using its 386-specific QEMM (Quarterdeck's expanded memory manager) to emulate expanded memory.

To determine compatibility with common hardware components, each board was tested with IBM's CGA and NSI Logic's Epic EGA video cards. Fast extended memory, serial port, and parallel ports were provided by Cheetah International's Cheetah Card and Intel's Above Board PS/AT, which could also be used for expanded memory. Both bus and serial versions of the Microsoft Mouse were tested, as was Zoom Telephonics's Zoom Modem 1200PC.

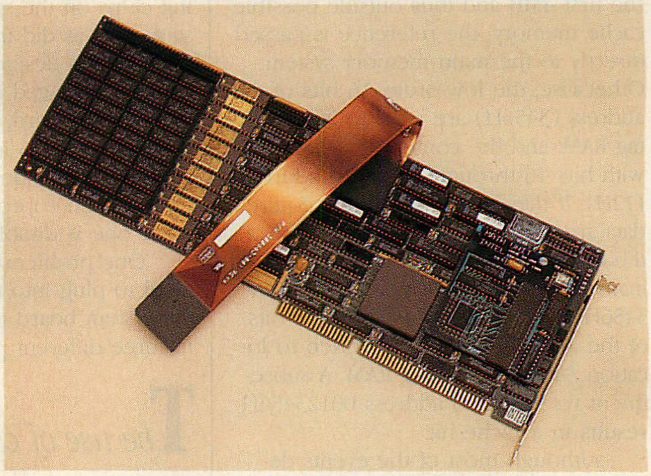
DMA was checked using Fifth Generation Systems' Fastback and a general system check was performed with the IBM AT Advanced Diagnostics.

PHOTO 1: ***American's 386 Turbo***



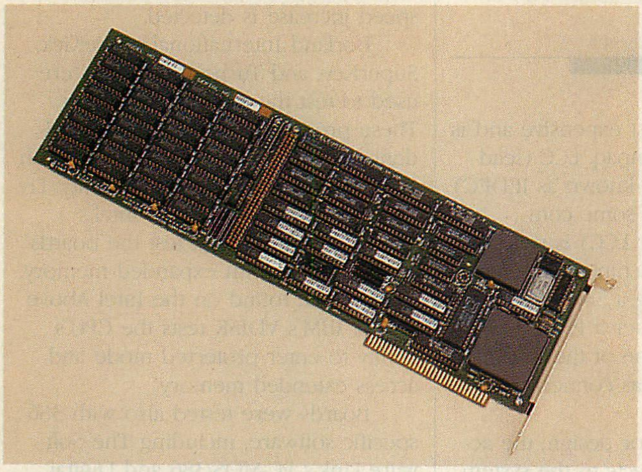
Although the simplest of the four board designs, the 386 Turbo has the most complex connection to the system board, consisting of two ribbon cables and a daughterboard.

PHOTO 3: ***Intel's Inboard 386/AT***



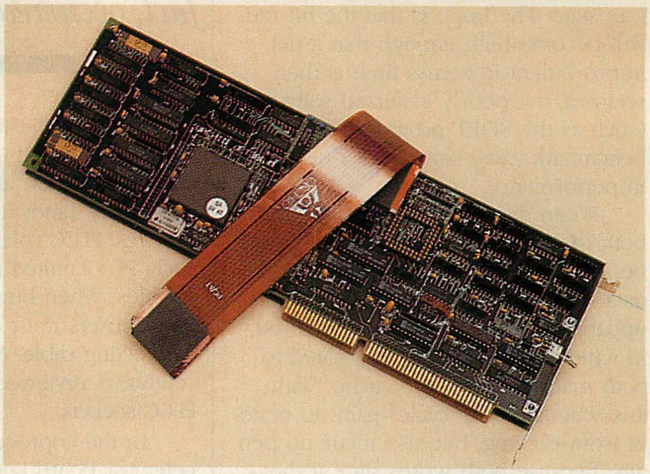
The connector to the system board is a flexible circuit, which is more reliable than a ribbon cable. The row of gold-colored static RAM chips implements the 64KB cache.

PHOTO 2: ***ARC's PC-ELEVATOR 386***



Because it is a coprocessor design, the PC-ELEVATOR does not need to connect to the system board at all and is therefore the simplest to install. It also works in the PC/XT.

PHOTO 4: ***Orchid's Jet 386***



Except for 64KB of high-speed cache, Jet 386 has no memory on board, but a piggyback board with 2MB can be attached to its underside. The connector is a flexible circuit.

Applications that were tested included Microsoft Word with both the bus and the serial Microsoft Mouse, MathSoft's MathCad, which makes extensive use of graphics and the math coprocessor, and Datastorm Technologies' Procomm, an asynchronous communications software package.

The benchmarks attempted to create a mix of potentially real applications, all running under DOS in real mode. The first benchmark is an assembly using MASM 4.00 of VDISK.ASM, a 75KB file containing the assembly code for the PC-DOS 3.3 version of VDISK.SYS, which is supplied with IBM PC-DOS 3.3. MASM and VDISK.ASM were both stored on a 512KB RAM disk, using IBM's VDISK operating in extended memory. Both the .OBJ and the .LST files were created on the VDISK. The batch file used was:

```
TIME 0
MASM VDISK,VDISK,VDISK;
TIME
```

The VDISK program needs an INCLUDE file that is not supplied. Removing the INCLUDE statement generates one error message, which is due to an undefined symbol.

The second benchmark is a run of the MS-DOS SORT filter on a 46KB text file, reading from and writing to the VDISK. The third benchmark uses the program PKXARC (a user-supported software program that maintains archive files) to test the integrity of a 1.5MB archive containing 41 files of widely varying sizes. The file is read from the hard disk and the results are then written to screen.

The next two benchmarks both test floating-point capability with MathCad, using some of the demonstration files packaged with the program. SPIRAL times the generation of a spiral with 11 rotations (22π radians). FOURIER builds an approximation to a square wave using N points; it was timed here with 400 points.

Remaining benchmarks test low-level hardware performance. ATPERF, the centerpiece of *PC Tech Journal*'s performance and compatibility metrics, generates a series of interesting statistics about memory access times, bus width, and system clock rates. ATFLOAT times execution of 100 iterations of a floating-point instruction mix. BUSPERF

TABLE 1: *386 Accelerator Board Features*

	AMERICAN	ARC	INTEL	ORCHID
PRODUCT	386 Turbo	PC-ELEVATOR 386	Inboard 386/AT	Jet 386
TYPE	Emulator	Coprocessor	Emulator	Emulator
MAXIMUM CLOCK RATE (MHz)	16	16	16	16
32-BIT MEMORY (MB)				
On board	1	1	1	0
Maximum[a]	1	16	3	2
CACHE MEMORY (KB)	–[b]	0	64	64
MATH COPROCESSOR SUPPORT				
80287	●	○	○[c]	●
80387	○	●	●	●
Clock rate (MHz)	5.3	16	16	5.3 to 16[d]

● = *Yes* ○ = *No*

[a] *PC-ELEVATOR 386 connects to one or more 4MB memory expansion boards in adjacent slots; Inboard 386/AT and Jet 386 accept 2MB piggyback memory expansion boards.*
[b] *On-board memory echoes lowest 1MB of system memory, acting as a 1-to-1 cache.*
[c] *Support for 80287 provided only on early models, now discontinued.*
[d] *80287 runs at 5.3 MHz if on system board, 8 or 10MHz if on Jet. 80387 on the Jet runs at 16 MHz.*

Emulator boards replace the 286 with a 386, and connect to the vacated CPU socket with a cable. Coprocessor boards add a 386 to the system, in effect creating two computers sharing peripherals and portions of main memory.

measures maximum bus bandwidth as compared with the original IBM PC. (For information about ATPERF and ATFLOAT, see "Out from the Shadow of IBM . . . " and "Updating the Evaluation Suite" by Ted Forgeron, Steven Armbrust, and Paul Pierce in August 1986, p. 52, and March 1987, p. 70; for BUSPERF, see "Speed Infusion," Ted Mirecki, February 1987, p. 126.)

The boards reviewed are shown in photos 1 through 4; their features are compared in table 1 and the test results are given in table 2.

American Computer and Peripheral. American implements its 386 Turbo card (see photo 1) with minimum hardware. It is an emulator that connects to the 286 socket on the system board; only a PGA connecting cable is available. It has no socket for a math coprocessor and only 1MB of RAM. This standard configuration, which has no provision for memory expansion or other options, costs $1,995. The CPU speed is switchable between slow (equal to the system board clock, 6 or 8 MHz) or fast (twice that rate).

If compatibility becomes a problem, the Turbo 386 includes a pair of Phoenix BIOS ROMs for the 386 (version 3.05). American suggests replacing the system board ROMs with these if compatibility problems occur. These ROMs were not tested.

The memory on 386 Turbo has only the simplest of mapping hardware; it resides in the bottom megabyte of address space, echoing whatever memory is there. Data written to the lowest megabyte are always duplicated on the board. For reading, each 64KB segment of on-board memory can be enabled separately, and then all reads from that segment will access the on-board memory instead of main memory. Utility programs are available to copy the BIOS and EGA ROMs and the video RAM into the on-board memory to allow high-speed 32-bit access to these areas. If all on-board segments are enabled, memory on 386 Turbo replaces the first megabyte of system memory.

The installation instructions suggest that the 286 be removed using an "unused bracket from the back panel" as a wedge. The bracket is just a little too thick to fit between a well-seated chip and its socket, but a jeweler's screwdriver might serve to lift the chip far enough out of its socket to use the bracket. On the test machine, the dent-puller chip extractor supplied with the Intel board was used.

The connector to the 286 socket is a small circuit board with two ribbon cables attached. Ribbon cables are more susceptible to noise and electromagnetic radiation than are flexible circuit cables, but these ribbon cables are short (about three inches) and designed to pass under any cards between 386 Turbo and the adapter.

According to American, its 386 Turbo board is designed to be installed in slot 6. In a 6-MHz AT, it is easier to install it in slot 5 because the ribbon cables are straighter. The cables are easily connected to two sets of pins mounted near the bottom of the board.

If a 287 math coprocessor is already in the system, no further changes are needed. If no 287 is to be used, American supplies a small adapter to insert into the empty socket so that the missing chip can be reliably detected.

The power-on speed of the board (equal to or double the system-board clock rate) is set by a jumper. Once up and running, the speed can be changed by software. American Computer made the hardware of this board as simple as possible. Consequently, the software speed switches on it are not implemented as ports, but as address decode circuits. A write of any value to a particular port address will toggle a state one way, and a read from the same address toggles it in reverse (without returning any meaningful value). However, the effects of a read and a write are not fixed, but depend on the position of the board jumpers.

For example, if the accelerator board has its jumper set to power up in fast mode, then a read from the board's base address enables the fast clock, and a write to the same address disables it. If the jumper is set for slow speed at power-up, the write enables the fast clock and the read disables it. It is not possible to read the board to get its current state, nor to set the board to a known state without knowing the jumper settings.

The quality of software provided with the board is not much better. American supplies a set of 21 files for changing modes, none of which is longer than 77 bytes; this does not leave much room for user friendliness. Instead of building intelligence into the software, American expects the user to determine the state of the board and choose an appropriate dumb program. Although the board has a port address switch, all programs assume that it is set to factory default and no method is provided to change them. Individual programs speed up or slow down the clock, turn on the cache, and so on; each has two variations, depending on the state of the jumpers. Other programs (independent of jumper settings) turn caching on and off for video RAM, EGA ROM, and BIOS ROM. The documentation includes several warnings about circumstances under which these programs will fail.

American also supplies a program called RUNT.EXE, which allows a speed switch from the keyboard. Its only user

TABLE 2: ***386 Accelerator Board Performance***

	IBM[a]	AMERICAN	ARC	INTEL	ORCHID
PRODUCT	PC/AT	386 Turbo	PC-ELEVATOR 386	Inboard 386/AT	Jet 386
PROGRAM TIMINGS (sec.)					
MASM	23	14	11	13	15
DOS SORT	32	27	13	18	18
PKXARC	104	60	48	49	55
MCAD Spiral	10	6	3	4	6
MCAD Fourier	30	19	19	12	18
ATFLOAT	90	78	15	47	80
ATPERF					
Memory performance (μs)					
Word fetch	0.40	0.13	0.14	0.13	0.13
Dword RAM read	N/A	0.26	0.20	0.27	0.26
Dword RAM write	N/A	1.05	0.13	0.27	0.26
Word ROM read	0.96	0.26	0.23	0.69	0.13
Byte video write	1.21	2.01	9.11	2.41	2.24
Wait states					
RAM read	1	2	1	2	2
RAM write	1	2	0	2	2
ROM read	1	0	1	2	0
Video write	7	30	172	55	51
Clock rates					
CPU clock (MHz)	8.0	16.0	16.0	16.0	16.0
Coprocessor clock (MHz)	5.3	5.3	15.7	10.0	5.3
Coprocessor type	80287	80287	80387	80287	80287
BUSPERF					
Bus bandwidth[b]	4.5	13.7	13.4	13.4	13.9

N/A = Not applicable

[a] The figures for the 8-MHz AT with a 30MB disk are provided as a basis for comparison.

[b] Values are ratios of the speed to that of a standard IBM PC running at 4.77 MHz.

All measurements were taken with the 386 accelerator boards configured for maximum clock rates and maximum benefit from caching. The results, therefore, represent the best-case performance that is attainable with each tested configuration. In practical applications, the speed improvement gained over an IBM PC/AT running at 8 MHz is slightly less than a factor of 2.

feedback is a change in cursor size to a large block when in fast mode. RUNT is created by a setup program that insists RUNT be placed on drive C: in the directory \T386. Although RUNT itself is less than 1KB, it consumes 16KB of system RAM when loaded.

In slow mode, American's 386 Turbo passed the IBM AT Advanced Diagnostics, with the exception of the math coprocessor test, which locked up the system with no error message. This was the only condition under which the 287 math coprocessor failed.

In both slow and fast modes, the board was highly compatible with a wide range of both hardware and software. Because 386 Turbo lacks an option for on-board extended RAM, it requires an add-on extended memory card, such as the Intel Above Board, to run 386-based operating systems.

The 386 Turbo board failed to run Microsoft Windows/386. Windows responded with "Unsupported Intel 80386 CPU version." The CPU shipped with 386 Turbo is an old revision (B0 step) of the 386. RUN386, from Phar Lap, also complained about this CPU. An engineer at the American Computer and Peripheral factory said in late September that American was shipping "16-bit S/W only" 386 chips, which have a known bug in the multiply microcode. He added that the company expects shortly to be shipping chips certified for 32-bit math.

Until then, the current supply of 386 chips are being tested by Intel for the presence of this bug; they are marked either "16-bit S/W only," if they fail, or ΣΣ, if they pass. Unmarked chips have not been tested, and checking a chip in the field for the bug's presence simply is not possible.

The 386 Turbo documentation consists of a reduced image of a daisy-wheel printer output, offset-printed and staple-bound. Most information needed by a technically knowledgeable user is present, but reading between the lines is required. Nontechnical users will not only have trouble installing this board, but also have more difficulty using the software that controls it.

Even running with an 8-MHz crystal installed, 386 Turbo is the slowest board tested, mainly due to its RAM design. At a price comparable with the other three accelerator boards, there seems little reason to recommend it.

Applied Reasoning Corporation. PC-ELEVATOR 386 (see photo 2) is far different from the other boards evaluated. A coprocessor design, it is actually a complete 386 system, with an on-board 387, 1MB of fast RAM, and timing support. Whenever it needs to access resources not on its own board (such as video, the keyboard, or anything else on the bus), it asks the system CPU, still running on the system board, to do the job and pass back the response. The result is a single-board computer that installs simply by inserting it into the system bus in any slot. Because it is able to use 8-bit slots, it can even be used in a regular PC or PC/XT.

The accelerator board with 1MB of RAM and no math coprocessor costs $1,995. The 16-MHz 387 math coprocessor is optional, at $795, from ARC. No 287 adapter board is available.

Memory is implemented as 1MB of fast RAM. This RAM can respond to a single read with zero wait states, but two successive reads require one wait state. A four-way, interleaved memory architecture is used, which means that the doubleword at address 0 is found in the first bank of chips, address 4 in the second bank, and so on. Address 16 (decimal) is found in the first bank again. Only when a read occurs twice in a single bank is a wait state required. Because the 386 always fetches 32 bits at a time and has a 16-byte prefetch queue, linear code executes with zero wait states. PC-ELEVATOR contains a connector for a 32-bit memory expansion bus; 4MB memory boards (using the same architecture described above) to connect to it should now be available from ARC.

PC-ELEVATOR 386 is the easiest to install of the boards evaluated. The board simply plugs into any open slot with no need for cables. There are four DIP switches mounted at a 90-degree angle along the top edge of the board. They are easily set from above without removing the card from its slot.

PC-ELEVATOR 386 comes with a setup program that configures the software for the board. The setup program should be run before closing the system cover because it suggests the positions of the board's DIP switches, based on the system configuration.

Because the main CPU is not affected by PC-ELEVATOR 386, the system boots up normally with the 286. The setup program then guides users through installation of the accelerator board. It asks about hardware configuration, displays a picture of its recommended switch settings, and asks users to set them the same. Users still can change the switch settings on the screen (for example, if an addressing conflict might possibly arise).

The setup program also allows allocation of the 386 memory pool into RAM disk, disk cache, main memory, extended memory, or expanded RAM (EMS) space. The software for doing this is easy to use and graphic. Any EMS already present in the system also can be used by PC-ELEVATOR 386. The amount of memory allocated to DOS can vary from 256KB to 640KB.

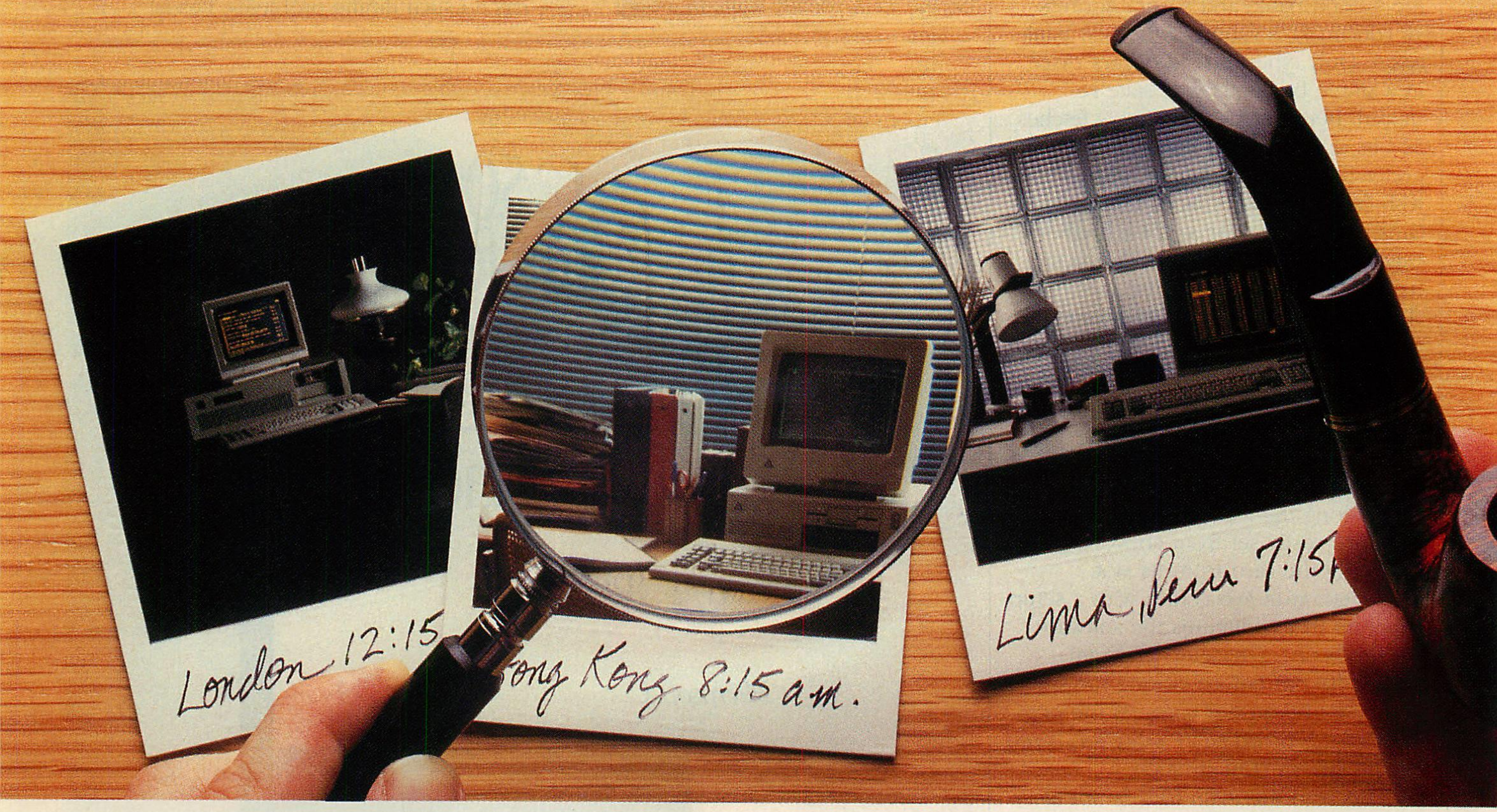
Once the setup procedure is complete, PC-ELEVATOR 386 is started by typing UP. This loads a kernel into the 386 at protection level 0, then causes the computer to reboot using that microprocessor. A device driver called UPDEV.SYS is loaded, providing memory partitioning as described above as well as an interface to the 286.

Compatibility in an environment such as this is more difficult, and indeed PC-ELEVATOR 386 has more compatibility problems than any other board tested. The biggest difficulty appears to be video on a CGA. Software that attempts to prevent snow from appearing on the CGA usually waits in a tight loop for the horizontal retrace to occur, then writes two or three characters out in the short time available. On PC-ELEVATOR 386, it takes a long time to get information from the host CPU—ATPERF shows an effective result of 172 wait states for video writes. Therefore, by the time the 386 finds out that retrace is occurring, it is already over, and snow results. Software that uses BIOS to handle the CGA performs better because PC-ELEVATOR 386 simply passes the entire task to the 286, which has no such timing problems. Ready!

London, 12:15 a.m.: Inventory File Updated
Hong Kong, 8:15 a.m.: Cash Receipt File Collected
Lima, 7:15 p.m.: The Day's Orders Retrieved

"Whodunnit?"

(Case No. 52 The Mystery of CCExpress)



"It was really the most extraordinary business...

"It seems several computers in distant parts of the world were intelligently accessed for the purpose of collecting and disseminating vital information for the next day's business activities at odd hours without the benefit of any human operator. They were efficiently reorganizing and transmitting their data to the PC of one Mr. Edward Drake of Trenton, New Jersey. Drake's alibi—a quiet dinner at home with his family at the time of these activities.

"The evidence decidedly pointed to Meridian Technology, Inc., one of the leading manufacturers of communications software. Meridian has developed a remarkable new communications software package referred to as "CCExpress." CCExpress allows fully automated, totally unattended, remote operation and file transfer between IBM PC, XT, AT and compatible computers.

"And the plot thickens. CCExpress also includes Carbon Copy PLUS, the only double feature in communications software, to make up a highly powerful tool for complete communications. An amazing piece of business...

"A few questions remained unanswered, so I rang Meridian at (714) 261-1199 and the rest was explained to me. By using the menus available in CCExpress, Drake instructed his computer to access the other computers in remote locations during lowered telephone rates and abnormal hours of operation.

"Drake's business savvy and the strategic advantage he afforded his company utilizing his computer 24 hours of the day with CCExpress was quite impressive! The mystery was solved."

CCExpress, around the clock and around the world.
Simply put, a vital link to your success.

MERIDIAN TECHNOLOGY INC

7 CORPORATE PARK ■ SUITE 100 ■ IRVINE, CALIFORNIA ■ 92714 ■ (714) 261-1199

CIRCLE NO. 230 ON READER SERVICE CARD

had serious display problems on the CGA, including an inability to change its background color. The program appeared to be using the color set for a monochrome monitor.

Ready! also failed to run in expanded memory on PC-ELEVATOR 386, with the error message "Attempt to DMA to address above 0BFFFFH." Ready! appears to copy itself into expanded memory using DMA, rather than using the more traditional REP MOV instruction. On PC-ELEVATOR 386, every access to an expanded memory on the system bus requires 286 CPU intervention because EMS memory is not directly addressable by the 386 processor. When asked about this problem, an ARC representative wondered, "Where did they [Living Videotext] get the idea they could do that?" He said IBM never stated that an add-in board (such as an EMS board) had to accept DMA accesses and that it was a bad assumption to make.

Other PC-ELEVATOR 386 incompatibilities include an inability to run the Advanced Diagnostic routines. The diagnostics even misidentified the CGA video board as an EGA board.

Because UPDEV.SYS runs at protection level zero, it rejects all 386 operating systems, such as The Software Link's PC-MOS/386. Quarterdeck's QEMM will not run, but its functions are provided by UPDEV, so Quarterdeck's DESQview ran correctly in emulated expanded memory. ARC designers say they "are discussing" various possibilities with software vendors.

The PC-ELEVATOR 386 documentation, in an 8.5-by-11-inch format, is rather poorly printed (it is marked "Ver 0.02"). The content, however, is excellent, written at an easily understandable level without talking down to the user. An entire chapter is devoted to troubleshooting, and appendixes are included with detailed technical information.

ARC was the only manufacturer to include a 387 on the board tested, which drastically improved its floating-point performance. However, PC-ELEVATOR 386's unique memory architecture afforded it a significant speed gain even on software that did not use the 387, such as the SORT program. For users looking for the easiest method of injecting tremendous speed into existing applications on a base PC system, PC-ELEVATOR 386 is an excellent solution.

Intel Corporation. Inboard 386/AT (see photo 3) is the most professionally packaged board of those reviewed. Small touches include storage cases for both the 286 and 287, an innovative dent-puller chip extraction tool, and a flexible circuit cable with no daughterboards attached.

Inboard 386/AT comes with a 64KB direct-mapped cache and optional 1MB of 32-bit, two wait-state RAM on the card. Intel also sells a 2MB piggyback board. Inboard with no RAM and no connector cable sells for $1,395. The system with 1MB of RAM installed is $1,695. Intel offers cable kits to handle PGA and LCC sockets; the required cable kit to match the particular computer is $200, raising the minimum price to $1,595. A piggyback RAM board with 1MB installed costs $695, 2MB installed is $1,195, and a 10-MHz 287 on a daughterboard that fits in the 387 socket formerly cost $495, but has been discontinued. A 16-MHz 387 costs $795.

Intel requires that the system board have an 8-MHz crystal installed, which they supply for use in 6-MHz machines. The board is set up to pass the speed-cop test with this crystal in place. A socket for a 387 is included, and 64KB of 32-bit-wide direct-mapped cache is implemented with static RAM.

Inboard has 8 bits of tag RAM, allowing all RAM within the first 16MB (all that an AT is capable of addressing) to be cached. All RAM in the system is cached, including the fast 32-bit RAM on Inboard, but no provision exists for caching ROM or video memory.

The flexible circuit cable supplied with Inboard (for connecting to the vacated 286 socket) is unusually simple, with a thin connector on each end and no additional components. The board as tested came with 1MB of 32-bit RAM, and connectors are supplied for a piggyback board that can provide up to 2MB of additional RAM space.

Intel provides the most comprehensive installation instructions of boards tested. If instructions are followed carefully, installation is straightforward. The most difficult part is setting the 12 DIP switches that configure the board. They are located across the top of the board, and are too easily changed inadvertently while the board is being installed.

Unfortunately, Intel makes no provision to use an existing 287. Any math coprocessor in the system must be replaced with an Intel-supplied 287 plug. Intel will sell a 387 or a 287 soldered to an adapter board. They do not sell an empty adapter board.

Intel provides a small dent-puller chip extraction tool for the 286. With the tool hooked under the edge of the chip (its base resting on the system board) and the knob tightened, the chip can be lifted gently from its socket without prying. Removing the CPU is less traumatic with this tool than with those supplied by other manufacturers. Small boxes are provided to store the removed 286 and 287 chips.

The board installs most easily in slots 5 or 6, and the flexible circuit cable is run over the top of any boards between Inboard and the 286 socket. If no piggyback board is installed, only one slot is consumed; with the piggyback board, the adjacent slot is able to accept only short boards.

Inboard 386/AT comes with various programs, several of which are device drivers, intended to be loaded in the CONFIG.SYS file. The INVOC.SYS file (which is short for invalid opcode) adds error handling for the additional interrupts that the 386 can generate due to error conditions.

SPEED.COM can be used to change the processor's speed from the DOS command line. Four speeds are provided; the accelerator board has a fast and slow clock, and can turn the cache on and off independently of the clock speed. Intel refers to these as speeds 1 (slowest), 2 (fast clock, no cache), 3 (slow clock, cache on), and 4 (fastest). SPEED.SYS provides the ability to change processor speeds with a hot-key combination at any time (Ctrl-Alt-Shift plus a digit 1 to 4).

Intel also provides IEMM386.SYS, a program that uses the 386 memory management facilities to emulate expanded memory with extended memory. This provides the same functions as QEMM. DESQview seems to work properly with both, but its memory status display behaves oddly. The "Largest Block Available" under IEMM is always 0KB. Intel customer support suggested using Quarterdeck's QEMM instead.

Although Inboard provides the option to turn off all but 256KB of lower system RAM, Intel did not see fit to supply a program that would force execution to take place in fast RAM.

The first and most obvious compatibility issue arose immediately after installing the board; IBM's SETUP program, which needs to configure memory size, hung instead of resetting the

system. It turns out that Inboard fails to reset properly under software unless SPEED.SYS is installed. Any software that reboots the system, including Intel's own SETUPAT (supplied with the Above Board PS/AT) will hang with Inboard. SPEED.SYS traps and corrects the most common problem of Ctrl-Alt-Del, but does nothing for programs that attempt to reboot on their own.

The first two times that Inboard was installed, it failed with a Parity Check 1 message when running Fastback at any speed. FCONFIG (Fastback's configuration and testing program) worked perfectly, including the DMA test. Fastback failed after writing a few tracks to the disk, even if it was configured with the /SLOW switch. The third time it was installed, it worked perfectly. An Intel representative said that the company uses Fastback on a daily basis without problems, running it on machines that are identical to the tested configuration.

Inboard 386/AT failed to run Microsoft Windows/386, which halted with the error message "Unsupported Intel 80386 CPU version." The packaging for Windows states that it will run with Inboard; this is apparently an older board with an older CPU chip.

Inboard was also unable to successfully complete the math coprocessor or keyboard routines in the Advanced Diagnostics. The math coprocessor test returned error 701, while the keyboard test returned error 300 and also hung the system.

Inboard's manual is a perfect-bound book printed in two colors, with many line illustrations. The installation section is detailed and straightforward, and is broken into three sections, one for each of the IBM AT, Compaq, and Tandy 3000 computers. The binding will not lay flat, forcing the user to find a weight to hold it open while attempting to follow the instructions. However, it is punched for an IBM-standard binder, and the pages can be popped out of the glued binding easily.

Intel makes the mistake of assuming that its users have no need for or interest in technical detail. The manual includes no detailed information about the theory and behavior of either hardware or software. In fact, it is often written down to users, for example, explaining that a "stronger" power supply might be needed.

Orchid Technology, Inc. Orchid's Jet 386 board (see photo 4) allows users a wide range of choices in setting up a machine. It allows use of, but does not require, the Jet RAM 32-bit RAM card. Similarly, the purchaser can install a 287 math coprocessor on the system board, a 387 or a 287 on the Jet 386 card, or no coprocessor at all. Jet 386 has a socket for the original 286 CPU, and a switch so that either that or the 386 can be the default CPU. The list price of Jet 386 without RAM or a math coprocessor is $1,299, and the required cable kit (PGA or LCC) to match the particular host costs $149. The Jet RAM card with 2MB costs $995. The 287 daughterboard for the 387 socket is $95; it allows use of an existing 287.

The system tested had a 10-MHz 287 math coprocessor with a system board adapter, and the optional Jet RAM card with a full complement of 2MB. The base Jet 386 board has no system RAM of its own, but does have a 64KB direct-mapped cache with 6 bits of tag RAM, capable of caching data read from within the first 4MB.

Four sockets, designed to accept the Jet RAM card and provide a 32-bit memory bus, are mounted on the back of the Jet 386 board. The Jet RAM card can also be inserted directly into the

system bus, but, if this is done, the Jet RAM is then limited to 16-bit transfers at a significant cost in speed.

An on-board socket for a 387 is present; Orchid sells the Jet/287 daughterboard, which allows a 287 to be used in this socket. Jet 386 comes standard with the 287 system board adapter, which allows use of the math coprocessor in its original socket (even if no math coprocessor is used, the adapter is still required). The flexible circuit cable that connects to the system board CPU socket is more reliable than a ribbon cable and attenuates both received and transmitted noise.

A small toggle switch on the back panel controls the choice of the CPU used when the system boots. Up, logically enough, indicates the 386. Changing this switch while the power is on usually resets the system (it performs a cold boot), but Orchid recommends against doing so if the Jet RAM card is installed. Orchid also provides software that switches between processors without the need for rebooting.

Jet 386 comes in several packages: one contains the Jet 386 board, another contains the Jet RAM card, and a third contains the flexible-circuit cable and additional installation hardware.

After the jumpers are set, the Jet RAM card installs on the back of Jet 386, with about a half-slot separation. Both are full-length boards, and somewhat less than full AT height.

Orchid likes to use daughterboards. A small printed circuit board (PCB) is attached to one end of the flexible circuit cable and another PCB for the 287 system board adapter is attached to the other end. Using the 287 on Jet 386 requires yet another daughterboard. A small ribbon cable connects the 287 system board adapter to a connector on Jet 386, close to the rear of the machine.

Normally, the 2MB on the Jet RAM card would be placed in extended memory, where in the current DOS environment it can only be used for a memory disk and a few obscure programs. Extended memory fares better on the 386; several programs cause it to emulate expanded memory (IEMM386 from Intel, QEMM from Quarterdeck). Because most software runs in the lower 640KB, Orchid allows a user to disable all but 256KB of system RAM on the system board, and fill in the difference with the Jet RAM card for greater speed running everyday applications. Disabling system board RAM on the AT is done by moving a jumper; all Jet 386 options are set with jumpers, not switches, which is somewhat inconvenient. Jet RAM options are set with jumpers that are then left between the two boards. These jumpers cannot be seen or changed without disassembling the entire Jet system.

Once its jumpers are set, installation is straightforward, but requires care. Orchid includes a chip extractor tool (a metal strip with a 90-degree bend at the end) for prying the 286

When booted in 286 mode, Orchid's Jet 386 is indistinguishable from native 286, but operation of the 287 was erratic.

from its socket. Getting the tab of Orchid's extractor firmly between the 286 and its socket proved to be an impossible task. However, Intel's dent-puller chip extractor easily pried the microprocessor out of its socket.

The board set can plug into any 16-bit slot on the AT. Because the Jet RAM card takes up room on the left of the board, and the daughterboards take space on the right, the system consumes at least 2½ slots (or 3, if the 287 system board adapter is used). Placing the card in the end slot (slot 8) would cut it to two. In the test machine, the disk controller resides in slot 8, and its cables are not long enough to allow it to be moved, so Jet 386 was installed in slot 6 instead.

Documentation for Jet 386 assumes that additional boards can be reinserted after the product is completely installed. However, the flexible circuit cable does not have enough slack to run it under the card in slot 8. Given the short cables, users must first install the system board connectors, reinstall the board in slot 8, connect the 287 cable to Jet 386, insert Jet 386 into slot 6, then finally connect the flexible circuit to the Jet 386 board.

Orchid mentions that the cable connecting the 287 to the Jet has connectors with pin 5 cut off, so that the cable cannot be reversed accidentally. The cable's corresponding plug does not prevent such a reversal, but the correct connection is fairly obvious.

Jet 386 comes with a device driver (JET386.SYS) that controls switching between 286 and 386 modes, as well as turns the cache on and off. The cache can be enabled for system RAM only, or for both RAM and ROM. No slow-clock 386 mode exists. This proved to be a disadvantage because some copy-protection schemes fail at high speeds; for example, Lotus 1-2-3 cannot run under 386 operating environments such as PC-MOS/386. JET.COM provides a simple method of controlling the device driver from the DOS command line. No hot key exists for changing caching or processors.

Because the 32-bit Jet RAM is so fast, Orchid provides JETSPEED.COM, which consumes just enough memory to run a new copy of COMMAND.COM at the 256KB boundary. It allows all applications to run entirely within Jet RAM (provided they fit in the 390KB of space remaining). Extra memory can be recovered easily by typing EXIT at the DOS prompt. This is preferable to the usual scenario of having a TSR consume the memory with no practical method to get it back.

The company also includes Orchid Productivity Software, a collection of utilities that provide a disk cache, a print spooler, a RAM disk, and AT-clock manipulation functions.

When booted in 286 mode, Jet 386 is essentially indistinguishable from native 286. Orchid says that it passes the IBM speed-cop ROM test, and all software tested ran correctly, as long as it did not require the 287. However, operation of the 287 from the 286 was erratic at best; it would usually generate incorrect results, and occasionally hang the system. Jet 386 caused the 287 to fail the math coprocessor test in the Advanced Diagnostics.

Orchid was unable to reproduce this failure in an identical configuration at its factory, and supplied a set of replacement boards (without a new 287). This board set failed in the same manner after it warmed up. A different 287 (80287-3) was tried in the first board set, and it also behaved erratically.

To the 286, Jet RAM has no advantage over system board RAM; both use one wait state for read and write accesses. The Jet RAM card only comes into its own with the 386, when its 32-bit data path can be used.

Jet 386 is highly compatible in 386 mode; the board ran every DOS program tried, including the system board test in the Advanced Diagnostics. It also successfully ran QEMM, PC-MOS/386, and Concurrent DOS 386.

Program intended for Phar Lap's RUN386 environment executed properly, but hung upon termination. Jet

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386 almost ran an early release of Windows/386—Windows started, sometimes displayed the mouse cursor and the main screen, then died with the message "1102—Please Reboot Your System." No errors were encountered with the 287 in high-speed mode.

Jet 386 operated correctly with all tested hardware except Intel's Above Board. It was unable to successfully load the Above Board driver EMM.SYS in any mode.

The cache only operates when the 80386 is running; it normally caches any RAM within the first 4MB that is not located on the Jet RAM card. The cache can also be enabled for the 64KB system ROM area at segment F000H. It significantly speeds some software, but can affect compatibility.

The cache consists of 64KB of 32-bit-wide zero-wait-state static RAM. A cache miss takes 10 to 12 wait states, which is actually slower in realtime than normal memory accesses on the 286. Poorly localized software (such as the SORT program) run as slowly on the 386 with the cache as they do on the 286. Disabling the cache makes them run more slowly.

Jet RAM is 32-bits wide at two wait states, and is not cached. Running JETSPEED first (so that the entire program ran in Jet RAM) caused the SORT program tested to run in about one-third the time.

The system memory access speed is affected by the crystal on the system board. Jet 386 took significantly longer (6 to 25 percent, depending on caching) to run the MASM benchmark with the system's original 12-MHz crystal installed. Orchid should include a 16-MHz crystal to let users eke out that last bit of speed.

The Jet 386 documentation is a small spiral-bound typeset book; it is both well organized and well laid out. Installation steps are clear. Users must read the Jet RAM instructions first because the Jet RAM manual is merely a replacement for incorrect sections of the Jet 386 manual. The manual itself contains many sketches to simplify installation. The only problem with Orchid's documentation is that referencing both books can be confusing; neither is indexed, but both manuals have good tables of contents.

Orchid supplies detailed programming information about the accelerator board, such as its I/O port assignments and the techniques used to switch its processor speed and enable the cache. A reference section details the myriad of software parameters.

THE SUM OF THE PARTS

The four accelerator boards reviewed here attack the same problem in rather different ways. Three succeed quite well and can be recommended.

American Computer and Peripheral supplies a 386 as simply as possible, without added features or options. If 386 Turbo were priced more appropriately (under $1,000), it might be a good choice for the experienced user on a budget, or for an OEM, as it is the most compatible of the four boards tested. However, given its lackluster performance and premium price, 386 Turbo has nothing to recommend it.

The four 386 accelerator boards reviewed attack the same problem in rather different ways. Three of them succeed quite well.

Intel Corporation and Orchid Technology made remarkably similar architectural choices with different implementations. Intel's Inboard 386/AT is easier to install, cleaner, and more self contained, especially in larger configurations. Its failure on the test machine to run Fastback for two out of three installations, however, is disturbing.

Orchid's Jet 386 also had its share of disquieting moments, such as the skittish 287 and Windows problems. Jet 386 and Inboard 386/AT are similarly priced for identical configurations, although Orchid's configurations are less expensive. For the minimum configuration with no RAM or math processor, Jet 386 is almost $100 less. Orchid offers a wider variety of math options; for those users willing to accept 287 math speed (which is by no means slow), Jet 386 is by far the less expensive choice. Intel no longer offers an alternative to the high-priced 387.

Where high-speed 32-bit RAM is concerned, Intel wins. It offers options of 1MB, 2MB, and 3MB, in a half-length board above 1MB. Orchid offers only the 2MB, full-size Jet RAM. Users looking to minimize space or maximize RAM should look to Intel.

Applied Reasoning Corporation's PC-ELEVATOR 386 is a rather different solution. It has a certain beauty in its implementation of both hardware and software. Large memory expansion options are promised for the future, but were not available at the time of this evaluation. If speed and ease of use are more of an issue than compatibility or growth to 386-based operating environments, then this is an excellent choice. For users upgrading from a PC or an XT, it is the only choice.

With three successes out of four tries, 386 accelerator boards are a viable approach to upgrading a computer to the next generation of performance. Apart from the increase in processing speed, the major advantage over a plain 286 system is entry into the growing world of 386 software. That alone makes this upgrade much more significant and desirable than merely upgrading to a 286 processor.

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Cambridge, MA 02140
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Orchid Technology, Inc.
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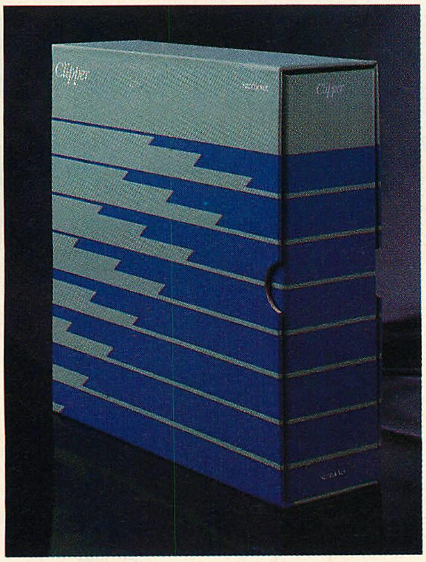

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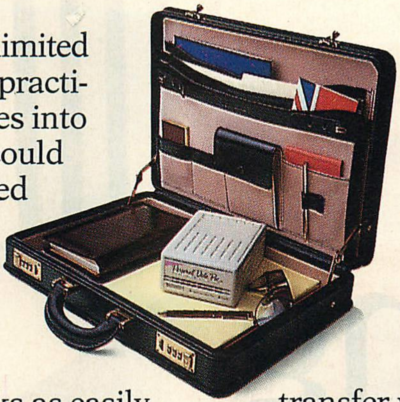

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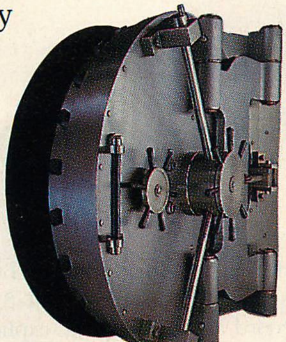

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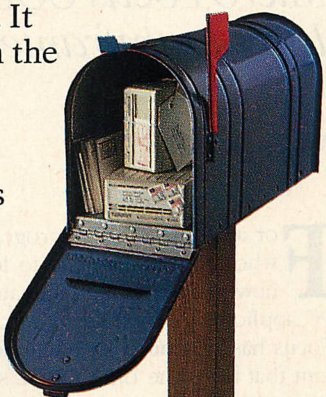

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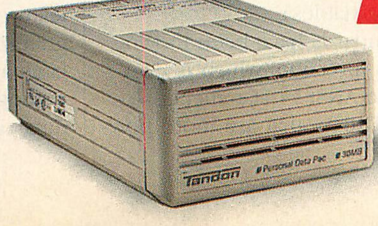

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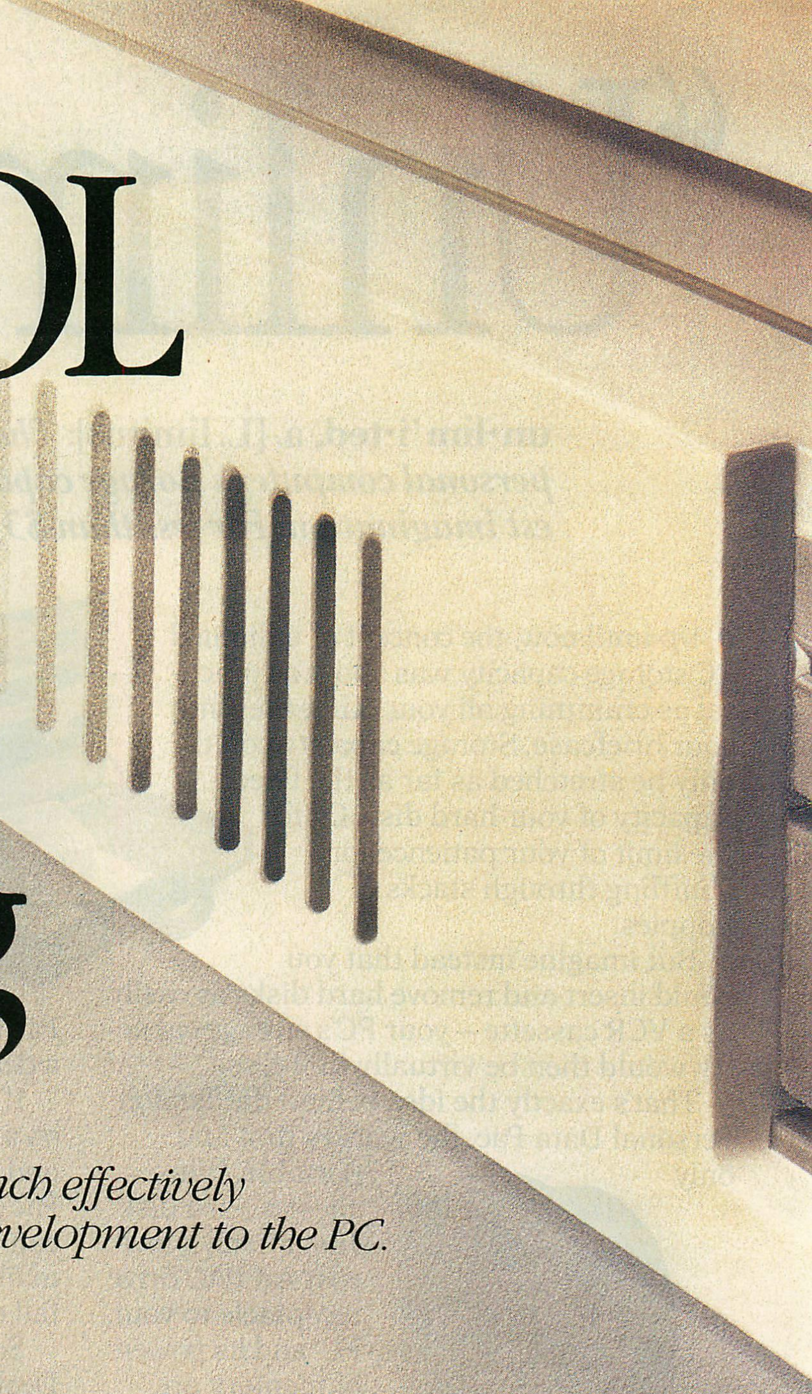

COBOL in a PC Setting

Micro Focus COBOL Workbench effectively lures mainframe program development to the PC.

MARY DEWOLF

For all those COBOL programmers who thought they had to learn a new programming language for PC applications, look again. Micro Focus has produced an integrated system that takes the old COBOL syntax beyond its batch-processing roots and into the interactive world. The Workbench provides development tools, service routines, and language extensions that make COBOL more useful in its traditionally weak areas of system interface, variable-length fields, and screen interaction.

Equally as important, the system includes compatibility extensions to allow source code to be exchanged between mainframe COBOL and the PC COBOL Workbench. The result is a surprisingly effective language for PC applications and a powerful enough development system to lure mainframe program development on the PC.

The COBOL language was developed in a time of simpler applications, when input-process-output was the basic logic structure and user interfaces were accomplished manually. Modernization of the language requires improved screen and keyboard handling, provision for variable-length fields, string-handling facilities, and linked lists (including memory management and address variables).

ANSI standards have been moving slowly in this direction, which is evidenced by the ANSI-74 statements, STRING\UNSTRING, that are more powerful and readable than their C counterparts **sprintf** and **sscanf**. ANSI-'85 adds record and file locking, explicit-length qualifiers on field names, and BY VALUE/BY REFERENCE clauses for CALL statements.

COBOL COMPATIBILITY

The Workbench's COBOL starts with a fully certified ANSI-74 language, then adds extensions to match features of IBM OS/VS COBOL, VS-COBOL II, and some ANSI-85 specifications.

Micro Focus extensions provide features specifically geared to PC programming. Programmers choose the language level that they wish to use by putting a $SET statement at the beginning of the source.

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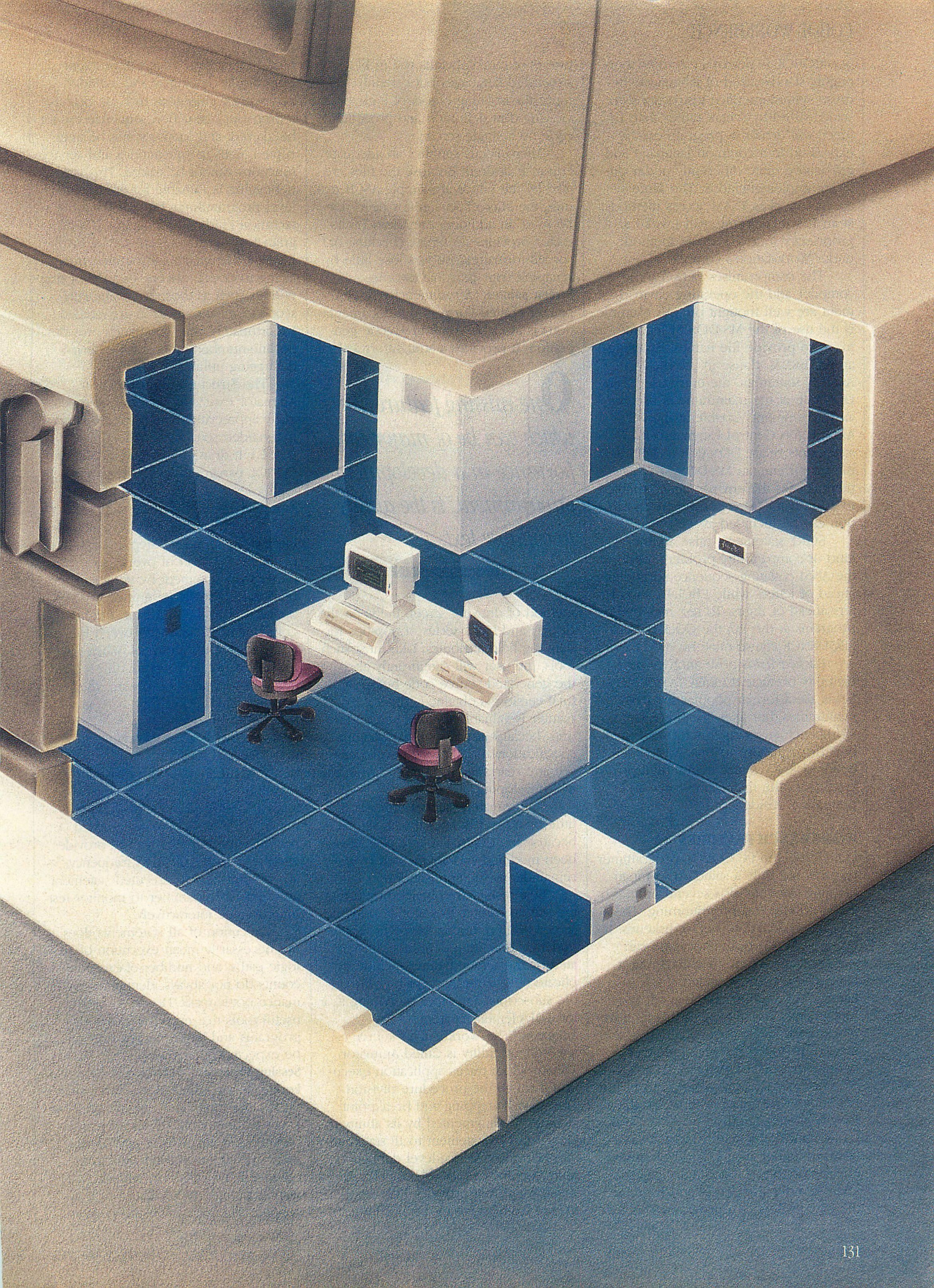

COBOL is perhaps the most thoroughly standardized of languages. Because system-interface instructions are standardized by syntax rather than by functional details, a program can be expressed in a common language and yet behave quite differently under different implementations. The same syntax that invokes VSAM access methods, at an IBM mainframe, will invoke a proprietary indexed access method under Workstation's compiler.

The compromises between the compiler and the operating environment are well thought out. An example is the use of the MS-DOS SET command to provide file names. By using an EXTERNAL clause in the file I/O ASSIGN statement, the entry used as a DDNAME at the mainframe is used as an Environment Variable at the PC. Also, as Job Control Language (JCL) statements relate DDNAME to DSN at the mainframe, an MS-DOS SET statement relates the environment variable to a file name. Drive and path information can be included as well.

SORT statements raise another kind of compatibility problem, because the ANSI collating sequence sorts digits ahead of letters while EBCDIC sorts letters ahead of digits. To test mainframe programs at the PC, the COLLATING SEQUENCE clause must be used.

Packed fields pose another compatibility obstacle. COMPUTATIONAL-3 fields are a format popular for IBM mainframes, but alien to an 8088. Workbench supports this format but only through conversions. Avoid such definitions if you are migrating a program from the mainframe to PC for permanent residence.

WORKBENCH FEATURES

For $3,290, the PC COBOL programmer receives not only a standard, compatible language, but also several utilities for more effective programming. The package is delivered on 10 diskettes. It requires 512KB of memory and can run on dual-diskette machines, but a hard disk is recommended.

Editor. The built-in editor is fast (a fundamental requirement), has intuitive block-move and indent capabilities, and most of its functions are single-entry options that can easily be rearranged by a keyboard-macro program to fit the behavior of an editor with which the user is already familiar.

One missing feature, which can be of major importance in a development environment, is the ability to collapse text—remove the details and examine the overall flow of a program. This feature is of more obvious use in block-structured languages but certainly has merit for isolating blocks of logic or viewing data definition and procedural code on a single screen.

Micro Focus supplies an adequate editor, if desired. Because the files created by the editor are simple ASCII text files, the Micro Focus editor need not be used. In addition, the Micro Focus editor provides no syntax checking or special formatting, so you lose little by retaining your personal favorite.

Screen painter. A rudimentary screen painter (called Form in the documentation) is available for source-code generation. It provides a straightforward

One missing feature, which can be of major importance in a development environment, is the ability to collapse text.

method of drawing screen fields on the display and has a series of pop-ups for defining field attributes. Like most such tools, the user will significantly alter the generated source code before a final version is obtained. The screen painter is valuable for new screen layouts, because it eases the row/column specification and allows a developer to see and rearrange the screen layout as it is developing.

Unfortunately, such a utility is of little or no use in later modifications, because the original source will have been modified and augmented by the remainder of the application.

Best results are obtained by using the screen painter to generate only the screen section, not an entire program skeleton. Data item definitions generated by the screen painter include duplicate field names, accept but mishandle subscripts, and label everything as a level-01 elementary item.

Animator. The Workbench's source-level debug utility is called Animator. This program traces application execution through the procedure division. The normal stepping and breakpoint facilities are augmented by its ability to jump from IF statement to IF statement.

Like most source-level debuggers, Animator does a nice job of program walkthrough but provides little information from which to diagnose a technical, rather than a logical, problem. Data display is clumsy and includes automatic conversions that can disguise a problem; instruction sequence cannot be altered, and loops cannot be interrupted. Calls to subroutines and service functions cannot be traced. This sort of debugging is valuable for applications level programming, but not for more technical kinds of debugging. If a program is using the system CALLs, invoking other language subroutines, interfacing to device drivers, etc., debugging utilities such as those from The Periscope Company or Atron are needed. Unfortunately, the Workbench provides no line-number support for external debugging utilities.

The Structure Animator is an Animator extension that will be especially appreciated by advocates of computer-aided software engineering (CASE). It draws block diagrams at the COBOL paragraph level, showing a higher-level flow through a program. Animator breakpoints and step commands apply at the block level, allowing a programmer to step through a program at a level of overall structure rather than statement by statement. Because the Structure Animator is an option within the Animator, the programmer can alternate between looking at the forest and the trees. When viewing an unfamiliar program, this feature allows a programmer to grasp the overall logic quickly, then zero in on the portion in question.

Analyzer. Analyzer is an adjunct to Animator that tracks statement execution in a highly interactive manner and is useful for source-level performance analysis or for ensuring that all paths through the code have been tested. A rudimentary graphing feature provides visualization of execution frequency, and a "find next unexecuted statement" allows the programmer to monitor testing coverage interactively.

Execution of all statements does not necessarily mean execution of all logic paths, and number-of-executions counts do not always identify performance bottlenecks. However, both are useful tools that encourage cleaner programs and better testing than can be expected otherwise.

Session Recorder. Session Recorder is a keystroke-recording facility that works off runtime interfaces rather than from keyboard interrupts. It strongly resembles the simpler uses of keyboard-macro programs, but benefits from being able to switch on and off, producing a single recording from noncontiguous events. By using Session

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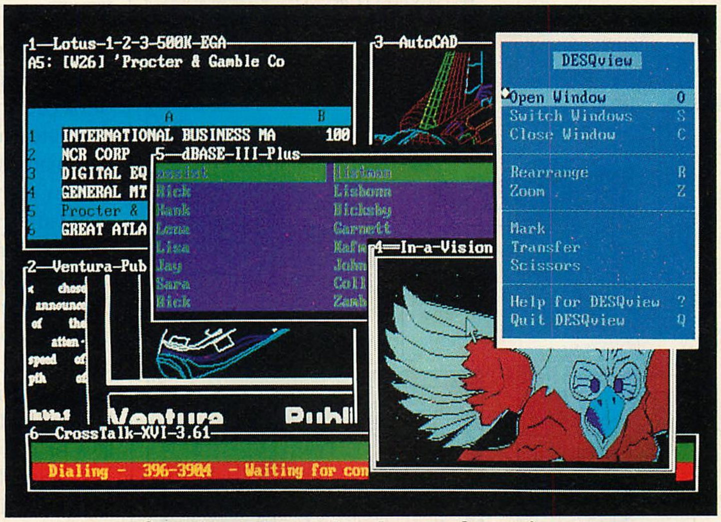

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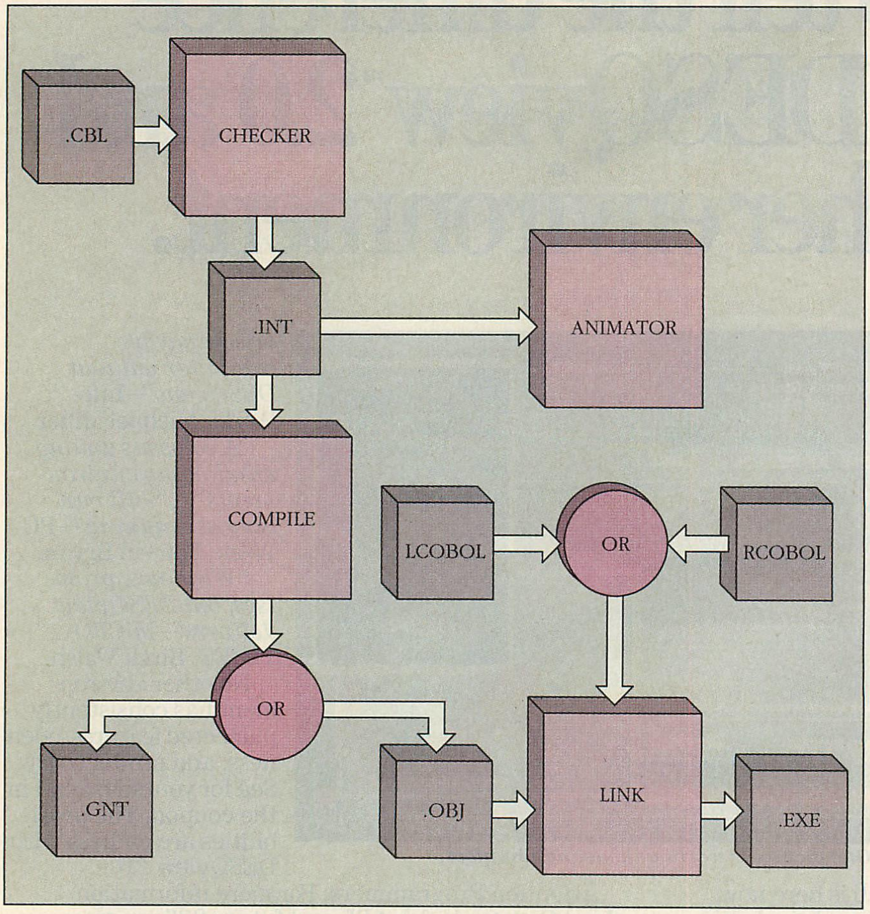
FIGURE 1: ***Syntax Checking and Compilation***



The Checker is a stand-alone syntax checker that produces intermediate code files for the compiler. The compile step generates either a .OBJ or a .GNT file. The .GNT file is executed via the runtime package; the .OBJ is used for linking.

Recorder along with the program Analyzer, a programmer can systematically test all paths through a program. Recordings from previous tests can be used for regression testing of a program undergoing later modifications.

The manual advises against using Session Recorder on a dual-diskette system, apparently because of the number of files that must be present during record and playback and the assumption that the same files exist on the same drives at playback time.

Driver. Components are tied together by a main-menu driver that provides quick movement and consistency between components. For example, the driver "remembers" the program name last entered and applies it to all options so that Edit, Check, and Animate can be done with only a confirming ENTER for the program name. Specific file suffixes are applied automatically.

Negotiating the menus from Edit to Check to Animate can be distracting. The problem is threefold: first of all, the editor's Load and Save options are hidden in the Alt menu, which is visible only while the Alt key is depressed; secondly, there is no save/end combination function; and, finally, there is no prompt for a file name when the Edit option is selected.

In general, the product would be helped by a more hierarchical menu structure, rather than the current monolithic lists of unrelated options. For example, cursor movement and insert/delete options appear in the same option list as save and restore of files, find-text functions, and Esc, such that the user must select from a list of 20 options in no obvious order. Some pull-down menus from group-item selections would be less distracting.

Compile/link tool. The compile/link cycle is a confusing array of options that appear to have been added on haphazardly as the product evolved. The Checker is really a first-pass syntax checker which produces intermediate code files for the compiler (see figure 1). The Workstation provides this first pass as a stand-alone program so that Animator and Analyzer can work on a pseudointerpretive basis using the intermediate code file as their input. In the figure, Compile represents the remaining passes. The Compile step does not read the source file, but reads the output of the Checker.

One of the critical performance aspects of a compiler is the quality of the error messages. The Checker's error messages are often cryptic and sometimes downright misleading. The following statement:

```
WRITE output-rec TO output-file
```

(in which the TO clause is spurious) yields an illegal-verb message. An underscore in a data name causes illegal-character messages on all subsequent data names. A PROMPT clause from the screen painter is mysteriously flagged as invalid parameter length.

Output of the Compile can be either a .OBJ or a .GNT file. The .GNT file is executed via the runtime package; the .OBJ is suitable for linkage editor input. Linking is discouraged in favor of using the runtime package, but is needed for programs that use overlays or call non-COBOL subroutines.

Two alternative link libraries are available: linking with LCOBOL.LIB produces a stand-alone .EXE file that will execute without the Workbench; linking with RCOBOL.LIB produces a smaller .EXE file that requires the runtime routines to be resident at execution.

The residency requirement can be a significant issue. The storage absorbed by the resident routine can be reclaimed only by system reset, which discourages automatic loading. On the other hand, the command that loads the resident module has no protection against loading multiple copies, so it cannot be easily incorporated into the application's .BAT file. For machines running a high percentage of Workbench applications, the resident routine can improve application performance. For machines in more general use, the linked module will be more practical.

The Workbench will execute in OS/2 by using a different command; no upgrade is necessary. The generated applications can be executed in either environment. If the compile generated a .GNT file it will be executable under either operating system; if a .OBJ was generated it will need to be relinked to change environments. No source-code alterations will be required, unless the program includes CALLs to system-dependent subroutines. This makes it possible to develop and test OS/2 applications now, under MS-DOS, without

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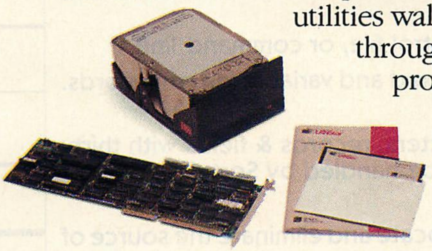

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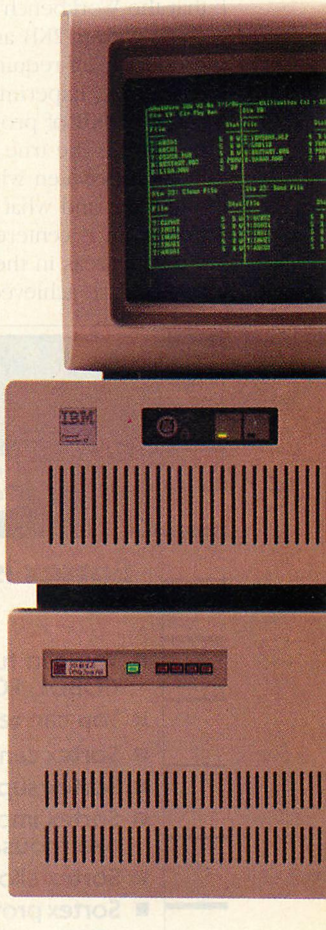

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waiting for OS/2 availability or dealing with Microsoft's OS/2 Software Development Kit. (RCOBOL.LIB will not be initially available under OS/2.)

Microsoft's linker is shipped with the product, but the LIB utility is not. Unless a LIB utility is obtained with some other language, all application subroutines must be explicitly named to the LINK command. If the program is segmented (overlaid), the compiler will generate link control statements for the overlays, but the programmer must still supply information for additional .OBJ files.

The documentation indicates that fields passed as parameters must be defined within the first 64KB of working storage. Micro Focus reports that this restriction can be eased by using a $SET option at compile time.

Installation. Micro Focus recommends that the Workbench be used on a machine with 512KB and a hard disk. The product itself requires about 2.5MB of disk space. Experimentation shows that about 350KB of program-available memory is the true minimum. The distinction between what can be done in minimum and what can be done in maximum is centered on the size of the data areas in the application. No benefits are achieved beyond 500KB of available space, and the system runs with no apparent problems in 425KB.

Execution-time requirements depend, of course, on the method used to execute the program. A program linked to use the resident module is smaller than the self-contained version, but the resident runtime module requires 150KB of its own. Thus, the total memory requirement for a stand-alone application is less than if the program is linked to use the resident routines.

Micro Focus offers an add-on product called XM that provides extended memory support for the compiled application. For exported mainframe applications designed for 16MB address spaces, relief is available.

Documentation. If the product has a serious flaw, it is the manuals. In need of proofreading, written from the program's perspective rather than the user's, plagued by vaguely defined terms and apparent synonyms, the documentation needs a serious overhaul. An example is the murky description of the screen section's SECURE: "the effect on the data is the same as it would be without the presence of the SECURE clause, but this effect does not appear on the screen."

A more prickly problem is that many seemingly obvious key words are not listed in the index. To find even some reserved words requires searching through four volumes of text. In 26 pages of an appendix describing compiler directives, there is no mention of where, when, or how such directives are specified. Sample programs used a $SET statement in the source, which is not listed in the index and does not seem to be mentioned anywhere.

One of the few impressive aspects of the documentation is the format used to describe nested options. The use of black boxes and indentations makes menu levels clear and enables quick view of both the current choices as well as their parents.

COBOL FOR THE PC

In the C world, language extensions are found in the form of subroutine libraries. Environment-dependent functions, such as access methods, string-handling utilities, and screen/keyboard I/O, can all be obtained in subroutine form. C is considered portable, not because its language syntax is generically applicable, but because environment-dependent instructions simply are not defined in the language.

In the COBOL world, these interfaces are not only defined, they also are a major focus of the language defi-

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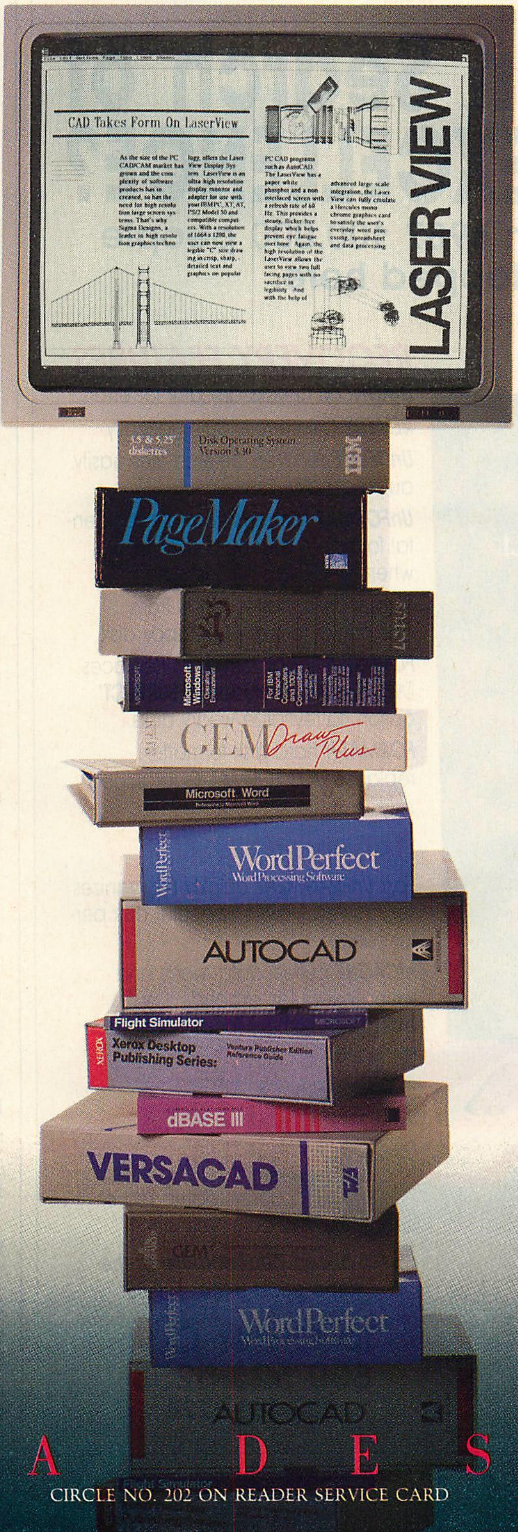

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S I G M A D E S I G N S

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nition. In order to meet the ANSI standard, the compiler developer must invent those services not available from the operating environment. The inclusion of indexed file management and screen handlers, for example, contributes significantly to the price of COBOL compilers for the PC.

Basic to screen I/O is the rejuvenated ACCEPT/DISPLAY syntax provided as a Micro Focus language extension. Both ACCEPT and DISPLAY allow specification of screen location, colors, some 3270-style cursor movement, justification, and minimal editing such as REQUIRED and LENGTH-CHECK.

(Mainframe programmers may be shocked to find the ACCEPT/DISPLAY statements back in favor after years of being banned by corporate coding standards and derided in COBOL programming classes. Mainframe ACCEPT statements took input from the system console, an idea that became ludicrous as mainframes grew larger and operators became less involved in program execution. Now that COBOL applications again have a dedicated operator, ACCEPT and DISPLAY can recover their original purpose.)

For processing multiple-field displays, the Workbench includes a screen definition component. ACCEPT and DISPLAY can name a screen rather than a single field to achieve the equivalent of a report writer's GENERATE statement. Screens are defined in the SCREEN SECTION of the data division, which describes screen fields, locations, attributes, and related data fields. The screen definition supports the OCCURS clause, allowing for repeating groups on the screen. No information is available on scrolling such groups when they exceed the screen's capacity.

Multiple panels may be displayed on the physical screen at the same time. There is no direct support for overlapping windows, but they can be accomplished by providing save/restore code within the application. (A Micro Focus add-on product called Panels addresses this need.) Pattern edits and "required input" can be specified for automatic editing, but content editing is available only between the individual ACCEPT statements.

Such restrictions tend to discourage intensely personal programs that depend on the close interaction among keyboard, program, and screen characteristics that are less appropriate to mainframe systems. This system is, after all, intended for applications programmers, not software developers, and the amount of time and complexity that such behavior costs is seldom justifiable in an in-house application.

Allowance is made for Esc handling, in a style analogous to the AT END clause in a READ statement. Function keys are reflected back to the application by the ACCEPT statement, via a SPECIAL-NAMES entry.

A limited form of address manipulation is provided by a Micro Focus extension, the TYPE IS POINTER clause. This option is intended for interfacing with non-COBOL programs, where address parameters may be required. There is no syntax for accessing the data pointed to, but careful use of the BY VALUE/BY REFERENCE clauses should allow one COBOL program to access data addressed by its caller's POINTER variable.

OFFLOADING TO THE PC

This compiler was built to be source-compatible with many varieties of mainframe COBOL, inviting large installations to offload mainframe development to PCs—a welcome suggestion for organizations that now recognize

the end user as their primary client. Operations staff often views programmers as both an overhead drain on computing power and the primary challenge to system integrity. This may be one instance when offloading to PCs does not appear to threaten the mainframe establishment.

For the programmer, there is something seductive about the PC that makes development there attractive. This is especially true in those mainframe shops experiencing slow response, excessive down time, limited development tools, or obstructive procedural requirements. Given the testing facilities included in the Workbench and the promise of "conversionless" movement between mainframe production and PC test environments, many programmers would find offloading a something-for-nothing opportunity.

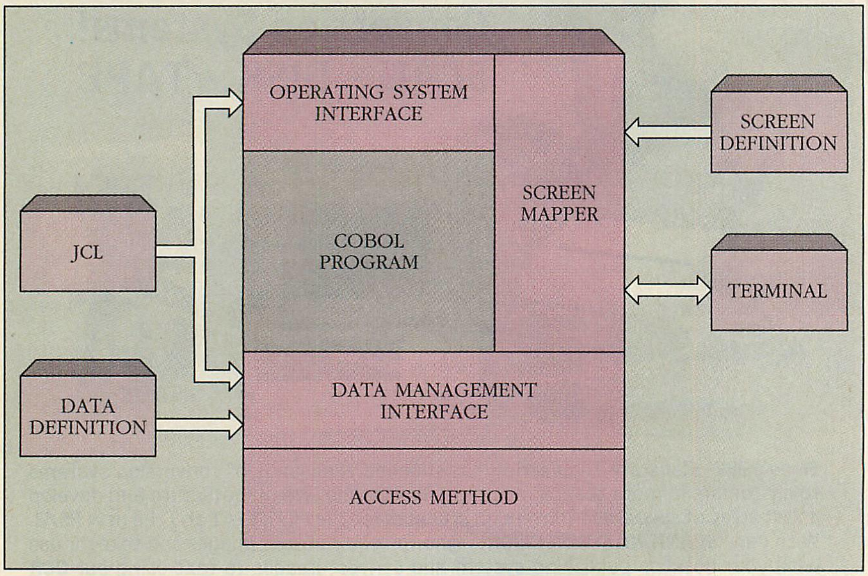
However, mainframe programming has become institutionalized over the last 20 years, and, like any institution, it includes many nuances in procedure and practice that need to be identified and considered before such a major change is attempted. Such rethinking can be valuable, even if no change in hardware occurs. Many of the tools offered by the Workbench have been available for mainframe systems, but they are seldom used and often unrecognized by applications programmers.

One overriding reason for doing mainframe development at the PC is easily demonstrated: push the PgDn key and see how long it takes to display the next page of text. A dedicated processor can give a programmer easier access to code; easier access to code will increase both the quality and the quantity of applications. This is the same argument that was made 10 years ago in the migration from keypunched source to desktop terminals.

Economy of scale is often outweighed by the "inefficiency" of waiting in line. Multitasking imposes overhead in terms of maintenance and operations as well as hardware cycles; shared resources inevitably impose procedural requirements and manual-intervention interruptions. Couple that with ongoing reversal of data processing economics (manpower costs rising, hardware costs dropping), and dedicated processors make sense.

CASE tools, often highly graphical and intensely interactive, are more suited to the PC environment. As the CASE movement gains momentum, pressure to offload such high-overhead processing from the mainframe will increase. Indeed, the very question of

Figure 2: ***Program and Supporting Services***



A mainframe program does not execute stand-alone. Access methods, memory allocation, terminal communications, operator messages, even screen formatting, are provided outside the application program. The application's program logic can be tested on the PC; however, it is not possible to test the entire application.

availability of CASE tools may dictate PC-based development. The Workbench's Structure Animator is an example of this new breed of tools.

While it is tempting to consider this powerful development system as a means of offloading mainframe development, several obstacles exist.

Productivity does not necessarily increase with faster response time. The programmer time spent on extra administrative tasks such as file transfer can be significant, especially if copy books and called subroutines are considered. Further, consider the argument that the increased interactiveness encourages a programmer to "twiddle," juggling logic and "tuning" long after the application is functioning.

Learning curves are steeper for a programmer who must master two disparate environments concurrently. And because the central staff does not have direct access to the programmer's system, they cannot provide the same level of service or support that was possible on the mainframe. Functions that were previously offloaded to the operations staff, such as backups and archives, must now be performed by the individual programmer.

Debugging on a PC can be much more difficult than debugging on a mainframe. A failing program at the PC yields no ABEND address, no memory dump, no ABEND code. Familiar errors will not produce their familiar symptoms. For example, most mainframe COBOL programmers know that an ABEND at location 48H or 50H is the result of an unopened file and that duplicate records at the end of a file probably indicate a missing CLOSE statement. The same unopened file at the PC will not provide such easily recognizable behavior.

A developer who does not work with his target system on a day-to-day basis, will lack the familiarity necessary to produce applications that fit snugly into that environment. Operating environments have conventions beyond their cut-and-dried interface requirements; most programmers have seen programs that, while they function correctly, do not use the expected control keys or screen facilities. A programmer therefore must adapt the program's behavior to the style expected on the target system. Further, a programmer who is unfamiliar with the utility functions of a target environment will end up reinventing functions already available in the target system. The result is higher development costs and inconsistent applications behavior.

A mainframe program does not execute in a vacuum. Access methods, memory allocation, terminal communications, operator messages, and even screen formatting are provided outside the application program (see figure 2). A programmer who tests a mainframe program is also testing the JCL, the screen maps, the access-method interfaces, the database definitions. PC-based testing exercises only the applications program—a small percentage of the execution unit. Micro Focus has screen-mapping translators in the wings, which promise to provide PC compatibility bridges to CICS and IMS screen maps but provide only source-code compatibility; mainframe testing of screen maps is still necessary.

Further, some inconsistencies always exist between compilers. Rounding algorithms never seem to match, system interfaces do not behave quite as expected, a good technique in one environment turns out to be a resource-eater in another. Off-line development can be an effective way to test program logic, but it needs to be clearly understood that *only* program logic is being put to the test.

Source-code libraries are shared files. Downloading copies of program source to PCs raises the old familiar problems of duplicate files and unsynchronized updates. Copy libraries and in-house subroutines only exacerbate the problem. Careful procedures must be set up to ensure currency and protect against conflicting modification.

The protections that have evolved over the years, usually built around a library-management product at the mainframe, are ineffective against multiple copies. PC development can be grafted onto an existing mainframe-based source-code management process, but the inconvenience and inadequate protection of such a procedure discourage its use. More effective options may be a LAN-based source library or a resurrected "team librarian" to track not only program versions but also multiple copies of those versions.

Statistics indicate that the vast majority of programming work is maintenance of existing code. Many of these projects involve relatively small code changes. The effort in the maintenance environment is not coding and only partly involves testing. In fact, this effort consists of understanding the system to be changed, determining how to implement the change, and performing the associated administrative functions of specification/sign-off, documentation updates, and production turnover. Development tools contribute only marginally to such projects. In many cases, the overhead of downloading and retransmitting the necessary source files only adds to the process.

The mainframe programmer normally edits a source file, SUBMITs a compile/link task, and then performs some other task while awaiting the results. In the single-threaded DOS envi-

ronment, the machine is not available for other tasks during the compilation process. The time spent waiting can easily negate any productivity gained by faster editor response.

Fortunately, 80286 computer users can eliminate this problem by upgrading to the multitasking OS/2 operating system, albeit at the cost of additional memory. Users of 8088- and 8086-based systems will require a computer or an accelerator board with a 286 or a 386 processor.

A more promising scenario is that of porting existing mainframe applications to the PC. Since this is a one-time conversion, it does not encounter the same overhead of movement between machines. Applications not dependent on shared files, executed by only a few users, should migrate easily. The Workbench's compatibility features, especially access-method support, would allow many applications to be moved, but not converted.

The danger of migrating mainframe applications is that a mainframe style is easily inherited as well. Programs originally developed for the mainframe tend to be conversational rather than interactive, with little keystroke support and no field-by-field edits. Running a mainframe-style application on a PC can be compared to harnessing an ox to a go-cart: wasteful from both perspectives. The most successful migrations may be those where the initial program is transplanted as is, and a round of changes to make it acceptable to a PC are scheduled as a second phase. That provides quick offloading of the mainframe and allows the end user to work with the program as a local application while there still is time to insert code changes.

OPTIMUM VALUE

Like many development tools, the Workbench's optimum value is in new development projects and major enhancements, in which the scope of the effort is sufficient to amortize cross-system overhead. The compatibility features minimize conversion efforts in offloading or distributing mainframe applications. However, this tool is not so productive for normal mainframe maintenance cycles, where coding makes up an even smaller percentage of the job. Those contemplating PC-based host application development should consider carefully the percentage of programming actually aided, and consider a LAN-resident source library system to minimize the movement of the data between machines.

COBOL is as ubiquitous to the mainframe programmer as the 3270 terminal is to IBM networks. Unlike "foreign" languages such as C or Pascal or database languages such as dBASE III PLUS, COBOL development tools will find ready acceptance among mainframe applications programmers. A familiar language can do much to bridge the gap to an unfamiliar operating environment. Just as the 3270 emulation boards enabled large-scale PC/mainframe communications, the availability of COBOL on the PC will encourage development of stand-alone and distributed PC applications.

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Mary DeWolf is the owner of This Is How, a Houston, Texas, consulting firm specializing in PC-host applications.

Measuring Numerical Accuracy

JIM ROBERTS

For the first time, a multilingual benchmark tests PC compilers for numerical accuracy.

When evaluating compiler performance, most tests time speed of compilation and execution, but few pay attention to the *quality* of output. Yet, for numeric computations, the most important measure of a compiler is not time, but accuracy. Knowing how fast a program can compute a wrong result is hardly useful.

PC Tech Journal therefore has developed a standardized test called ACCURACY to provide this missing link; it is designed to measure a compiler's computational *accuracy*. The ACCURACY program works across several different computer languages.

Although ACCURACY's primary purpose is to test the accuracy of computations, it is also substantial and well-balanced enough to give users a fair indication of other performance measures such as code size, compilation time, and execution speed for numerical programs. Its time is spent mainly in additions and multiplications, where smart numerical programmers spend theirs. Because the program is not a simple, single algorithm, it should reliably indicate overall performance in numerical applications.

This article evaluates the accuracy of 14 native-code compilers that use the Intel 8087/287/387 series of coprocessors for double-precision calculations. Four different algorithmic languages are included in our tests: C, BASIC, FORTRAN, and Pascal. The ACCURACY program was rewritten in each of these languages. See listing 1, ACCURACY.C, for the C version; the versions in the other languages are available on PCTECHline. Several Modula-2 compilers also were examined; however, none of them could produce meaningful results.

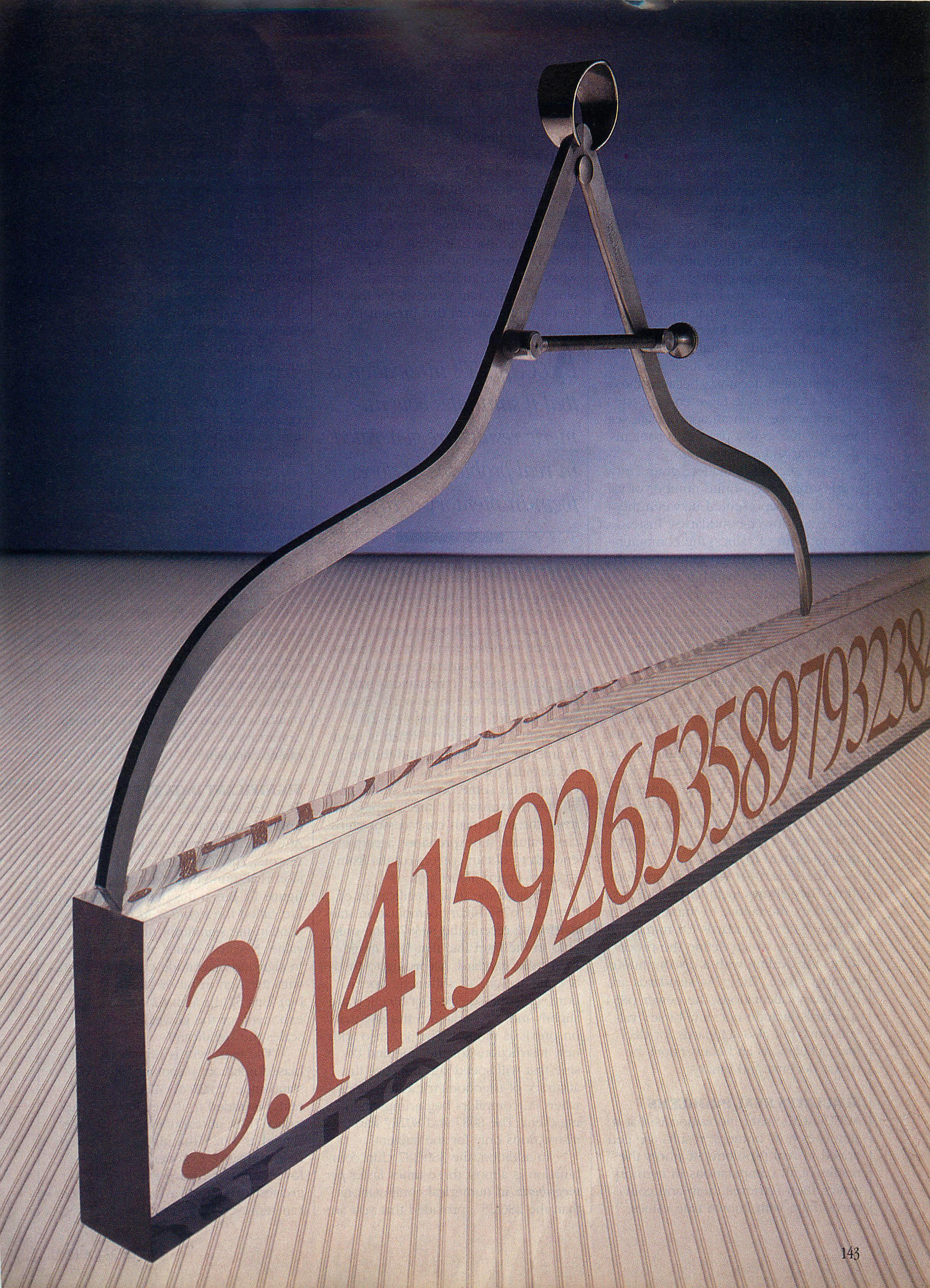
All the compilers examined and their vendors are listed at the end of this article. (For comprehensive reviews of these compilers, see "BASIC Face-off," Justin Crom, September 1987, p. 136, and "FORTRAN Perspectives," John Voglewede, June 1987, p. 92. Test results on additional C compilers and on more recent versions of those tested here will be included in an upcoming review of compilers.) Software emulation of the coprocessors was not considered, because no one doing serious numerical work would be without the actual chip.

ACCURACY's results should not be the sole criterion for choosing a compiler, but the test does help users select the best compilers for numerical work. *PC Tech Journal* intends to use it in all future compiler evaluations, in the hope that it can contribute to future improvements in the numerical performance of PC compilers.

ROOM FOR ERROR

Computational errors in computer arithmetic usually are caused by the differences between a real-number sys-

PHOTOGRAPHY • DON CARSTENS


3.141592653589793238

tem and its practical implementation in a finite automaton, such as a digital computer. In mathematics, however, the real-number system is infinite as well as continuous. Therefore, it imposes no limit on the magnitude of numbers in a calculation, and the interval between any two real numbers contains an infinity of values.

A computer, on the other hand, is finite—no matter how large it is. It cannot operate on the entire infinite real-number system, but only on an approximation that is both finite and granular. This means that the computer imposes upper and lower boundaries on the magnitude of numbers that can be represented. This in itself does not seriously limit accuracy, because the range can be made large enough to accommodate, with an appropriate scaling of values, most practical problems in science and engineering.

The second limitation, granularity, means that only a finite number of values can be represented between the upper and lower boundaries. Instead of a continuum of values, the computer provides a set of discrete numbers that are separated by small but real gaps. Most computational errors are caused when the calculated results fall within these gaps. Variations in accuracy are caused by the effective size of these gaps and by the procedures used to map a result to one end or the other of a nonrepresentable interval.

The ACCURACY program gives a quick but fair evaluation of how well 8087-assisted numerical calculations are implemented in PC compilers. It does not, however, diagnose the causes for any variations, either from function to function or from compiler to compiler. It is instead a phenomenological program designed for users.

The causes for variations are complex. They always include, but are not limited to, the failure to implement the IEEE p754/854 standards for numerical computation, which define the procedures for dealing with a discontinuous number space. The p754 standards are for binary calculations; the newer p854 standards include not only binary calculations, but also standards for decimal calculations and conversions between decimal and binary.

SIMULATES REAL PROBLEMS

ACCURACY's main innovation is that it simulates how numeric results are generated in real problems. It stores the results of all computations in memory arrays, then retrieves them and compares them with known true values. The more usual practice of using mutually inverse functions in the same expression, such as in exp(ln(x)) or $\sqrt{(x^{**}2)}$, is not a realistic test because the second function operates potentially on a higher-precision intermediate value instead of the native precision of the implementation. This is not how computations are done in practice.

Scientific and engineering calculations commonly manipulate numbers stored in several fairly large arrays, which are then modified iteratively while the program searches for the solution to a problem that presumably is well posed. In these iterations, seemingly small errors may mushroom and compromise the solution.

ACCURACY's innovation is that it simulates how numeric results are generated in real problems; it stores them in memory arrays.

Even a straightforward evaluation of some common formulas can lead to large errors or numerical instability if the floating-point computations have been implemented improperly. Examples of such formulas are $(1 + i)^n$ for small i and large n (which is used in interest calculations), and the familiar formula for the roots of a quadratic equation for some domains of the coefficients. Fortunately, if the compiler allows, the Intel math coprocessor chips can evaluate subexpressions accurately enough to obtain correct results from straightforward algorithms.

Because the final specification of the IEEE p754 binary computation standard is so recent, the 80387is the only chip in the Intel line that fully implements the standard. According to Intel documentation, all arithmetic operations, plus the square-root function are slightly more accurate on the 387 than on previous models. The 387 also adds new instructions for the sine and cosine that will speed and improve the accuracy of trigonometric calculations when PC compilers begin implementing them. The 8087 and 80287 have instructions only for the tangent.

In addition, the 386/387 chip combination is almost three times faster *per megahertz* in numerical computations than the 286/287, provided that you are using a compiler that fully exploits the 386/387. The 387 math coprocessor is a much greater upgrade over the 287 than the 287 was over the 8087 in terms of computational integrity, accuracy, and performance. However, at the present time, few compilers support the specific computational characteristics of the 387. Instead, they treat it merely as a faster 287.

ACCURACY is written for the 64-bit double-precision data type, but the test is not otherwise tied to any architecture. This independence from any specific hardware implementation means that it can be used, as is, on any system that supports 64-bit double-precision arithmetic. It can work on workstations using radically different hardware from the PC, with or without a math coprocessor, and under any operating system. It also can be used on minicomputers and mainframes.

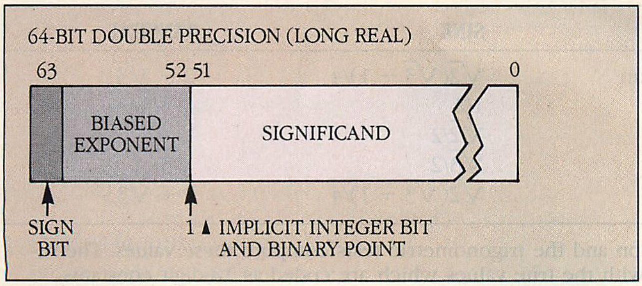
The ACCURACY program is a purely high-level implementation and not computationally sophisticated. It makes no attempt to access the chip directly, to test individual instructions, or to diagnose modes of calculation. It is meant solely to test overall numerical accuracy in computations that a scientist or engineer might perform. It contains algorithms and program structures similar to those written for engineering and science, including matrix multiplication, iteration, transcendental functions, extremely accurate mathematical constants, and the use of memory arrays to store values for subsequent calculations.

SIGNIFICANT DATA TYPES

Two real data types are relevant to understanding the operation of the ACCURACY program on Intel processors. The long real, or double-precision real, number is 64 bits long (see figure 1). Bits 0 through 51 collectively are called the *significand* because they contain the significant figures of the value. Negative values are represented in sign-and-magnitude binary notation with the sign in bit 63 (the high-order bit). Bits 52 through 62 contain the exponent, or the power of 2, that scales the significand.

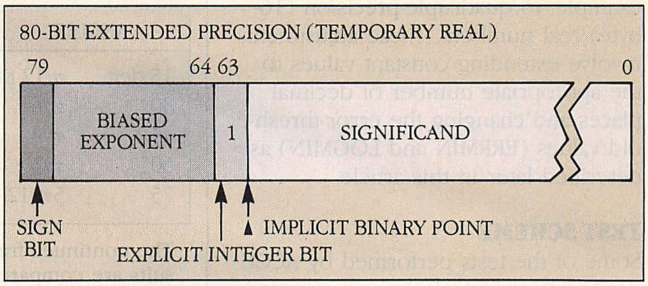
The exponent is represented in biased notation, meaning that a constant value (1,023 or 3FFH for long reals) is added to the exponent's true value. Thus, an exponent of 0 is represented as 1,023; the higher values represent positive exponents and the lower values negative exponents. The greatest magnitude a long-real number can represent is approximately 10^{308}.

FIGURE 1: *Long Real Number Format*



The 64-bit long real format conforms to the IEEE standard for binary computation. It provides 16 digits of accuracy.

FIGURE 2: *Temporary Real Format*



The 80-bit temporary real format that is used internally by Intel coprocessor chips provides 19 digits of accuracy.

The Intel coprocessors perform all calculations with an 80-bit extended, double-precision (temporary real) data type having an analogous structure (see figure 2). The longer significand field of 64 bits allows greater precision, and the longer exponent field of 15 bits accommodates a larger range of magnitudes, up to about 10^{4932}. The exponent bias factor is 16,383 or 3FFFH. The coprocessor has an eight-register stack of these temporary real numbers.

The IEEE standard specifies that a value's representation should be normalized so that the integer bit is always 1. Because its value is fixed, this bit need not be represented explicitly. This effectively extends the precision of the significand to 53 bits. An all-0 significand therefore represents the value $1*2^n$, where n is the value of the exponent field minus the bias value.

To represent the value 0, an exception is necessary; if the exponent field is also 0, the value of the number is taken to be 0, not $1*2^{-1023}$. The temporary real type expresses the integer bit explicitly, so that the 80-bit real number has only 64 bits of precision.

The unaided 64-bit data type for double-precision, floating-point numbers provides accuracy to a little less than 16 decimal digits. Significant additional accuracy measured in any test could result from guard and sticky bits, intelligent rounding, use of extended real values for long constants, or sophisticated conversion between decimal and binary representations.

An intelligent use of 80-bit temporary real values, either on the coprocessor's register stack or its extension in memory, can help preserve some or all of the additional accuracy of the chip firmware in intermediate results. The 80-bit data type gives an additional accuracy of three or four decimal places (11 bits), bringing the total to a little more than 19 decimal digits.

In comparing calculated results with the expected values, ACCURACY deliberately avoids the 80-bit data type in order to write a general and fair program. When measuring errors, the compared quantities should have the same number of significant figures. For example, when a 64-bit real number fetched from memory is compared with a number that remains in an 80-bit register after a calculation (and therefore has never been rounded or truncated to 64 bits), the difference is not a consistent measure of error. Both numbers must have the same storage history. (This was pointed out by Borland's software engineers to explain some mystifying results from the first version of ACCURACY.)

Because data must be saved to memory to compare quantities of the same length, ACCURACY cannot determine if the added precision afforded by the 80-bit temporary real format is used in intermediate expressions. This is consistent with its objective to measure the final accuracy of computations, not to determine the implementation of computational methods.

It is easy to adjust ACCURACY for different lengths of real numbers—for example, to quadruple-precision (16-byte) real numbers. These adjustments involve extending constant values to the appropriate number of decimal places and changing the error-threshold values (ERRMIN and LOGMIN) as described later in this article.

TABLE 1: ***Selected Values of Sine and Tangent***

ANGLES		SINE	TANGENT
15 deg	$\pi/12$ radian	$\sqrt{2}(\sqrt{3}-1)/4$	$2-\sqrt{3}$
30	$\pi/6$	1/2	$\sqrt{3}/3$
45	$\pi/4$	$\sqrt{2}/2$	1
60	$\pi/3$	$\sqrt{3}/2$	$\sqrt{3}$
75	$5\pi/12$	$\sqrt{2}(\sqrt{3}+1)/4$	$2+\sqrt{3}$

The continued-fraction and the trigonometric tests compute these values. The results are compared with the true values which are coded as 18-digit constants.

TEST SCHEME

Some of the tests performed by ACCURACY may at first glance seem somewhat more arcane mathematically than is absolutely necessary to test numerical computations. However, the tests are actually quite simple compared with real applications. Moreover, benchmarks should be complex if they are to imitate real applications—and make it impossible for compiler manufacturers to fine-tune to the benchmark.

Some effort has been made to segregate different types of computations into three separate series of tests. In Series 1, the tests measures ordinary arithmetic, including addition, subtraction, multiplication, and division. One test measures primarily addition and multiplication by multiplying a matrix by its inverse and measuring the errors in the product. The second test in Series 1 measures division accuracy by evaluating known numbers by means of infinite products and continued fractions. In Series 2, the tests gauge the accuracy of the trigonometric functions sine, tangent, and arctangent by comparing their calculated values with known exact nontranscendental values. Series 3 evaluates logarithms, exponents, the square root and, in the case of Pascal, the square.

For the trigonometric tests, the tangent is less accurate (in absolute terms) than the sine because its range is larger over the same domain of argument. The arctangent conversely is intrinsically more accurate than the arcsine; that is, the tangent is a better measure of angle than the sine is. Oddly, standard Pascal and Modula-2 do not have a tangent function, so ACCURACY uses the quotient of the sine and cosine for these compilers.

Each type of test was performed multiple times by varying a controlling parameter. The arithmetic tests, which are more demanding, were each performed five times; most of the function tests were performed 50 times each. For example, the trigonometric functions were evaluated and tested at five angles in the principal quadrant for which all the functions have simple nontranscendental values. Then they were tested in other quadrants. Table 1 shows the values of the angle and the corresponding values of the sine and tangent; the angles are given in both degrees and radians.

Errors are computed in relative, rather than in absolute terms so that they can be compared meaningfully and can be averaged from test to test. The relative error is the absolute value of the difference between the computed value and the known value, divided by the true value.

MATH TESTS

Readers who have studied algorithmic analysis, as presented in the first chapter of the well-known book, *The Art of Computer Programming, Volume 1, Fundamental Algorithms*, by Donald Knuth (Addison-Wesley, 1973), will be quite familiar with the mathematics used in these tests.

Series 1—multiplication and addition. Combinatorial matrices are used in computer science to analyze t-nary trees, but we make no such theoretical use of these matrices. The combinatorial matrix is a simple square matrix with the elements defined by the following equation:

$$a_{ij} = y + \delta_{ij}x$$

where $\delta_{ij} = 1$ for $i = j$ and 0 otherwise. In this equation, x and y have no special significance other than to indicate that the elements on the diagonal differ from the elements off the diagonal and that only two values are of concern. In the ACCURACY test, y is arbitrarily chosen as 1 and x is varied to produce a different matrix for each of the test's five iterations.

The combinatorial matrix is useful because it has a surprisingly simple inverse matrix with the elements

$$(-y + \delta_{ij})(x + ny)/x(x + ny)$$

where n is the dimension of the matrix, and x and y define the combinatorial matrix itself.

When a matrix is multiplied by its inverse, the theoretical product matrix is the identity; the diagonal elements of this matrix are all 1, and the off-diagonal elements are exactly 0. The identity matrix can be written as δ_{ij}, which is 1 on the diagonal and 0 elsewhere. Because computers use numbers with only a finite precision, the product matrix that is calculated is not exactly equal to the identity.

ACCURACY uses a small 10-by-10 combinatorial matrix that is well conditioned, not nearly singular. Poorly conditioned matrices produce large errors in their inverses. These errors, however, are more indicative of the length of the floating-point numbers used than of how well the computations are implemented. As shown in the first equation, the parameter x distinguishes the diagonal elements from those off the diagonal. Thus, as x is decreased, the matrix becomes more singular; x is varied to increase the tendency to error in a controlled way.

The accumulated truncation error is used in the product matrix to measure the accuracy of the program making the calculation. The ACCURACY program computes the average absolute value of the error in all 100 elements of the product matrix, which approximates the identity.

Series 1—division and subtraction. To test division and subtraction, two different series of tests were included to balance the test with the combinatorial matrix test for multiplication and addition. The first test of the division operation uses an infinite product run upside down. The infinite product is written formally as:

$$\frac{1}{1-x} = \prod_{k=0}^{\infty}(1 + x^{2^k})$$

for $0 < x < 1$ (from *Tables of Integrals, Series and Products*, I. S. Gradshteyn and I. M. Ryzhik, Academic Press, 1965, p. 12). The Π indicates that the series of terms for all non-negative

integral values of k should be multiplied together as follows:

$$\frac{1}{1-x} = (1 + x^1)(1 + x^2)(1 + x^4)(1 + x^8)(1 + x^{16}) \ldots$$

The validity of this formula is easy to demonstrate with simple algebra. Multiply both sides of the above equation by $1 - x$. On the left you have 1; on the right $1 - x$ combines with the first term, $1 + x$, to produce $1 - x^2$. But this term itself combines with the next term to produce $1 - x^4$, which combines with the next and so on, with each multiplication producing a higher power of x. Because x is less than 1, x^n approaches 0 as n increases; therefore the value on the right-hand side of the equation approaches 1.

The algorithm in this ACCURACY test inverts the infinite-product equation to divide 1 by successive terms from the product to achieve the desired approximation to $1 - x$. This test was run for five different values of x, each successively closer to 1. The closer x is to 1, the more terms are required, because x^n decreases more slowly with increasing n for larger x. In addition, the relative error of the computation increases as x approaches 1, reflecting the fact that when two numbers very close in value are subtracted, the difference has fewer significant figures than the values subtracted.

The next division test evaluates a continued-fraction approximation of the tangent function. Continued fractions are better known to pure mathematicians than to numerical analysts, yet they are very simple to implement in a program and they converge surprisingly rapidly to the value of the function represented. For the same calculating effort, they are usually more accurate than the common rational-function approximations but often do not converge uniformly throughout the domain of the function being calculated. Moreover, they are known only for comparatively few functions.

The continued fraction for the tangent is written as

$$\tan(z) = \frac{z}{1-}\ \frac{z^2}{3-}\ \frac{z^2}{5-}\ \frac{z^2}{7-} \ldots$$

where successive terms in the sequence are understood to be brought down into the denominator of the term on the left and subtracted from the odd number (see *Handbook of Mathematical Functions*, Milton Abramowitz and Irene Stegun, editors, National Bureau of Standards, 1964). The continued fraction that is written in this manner grows diagonally down the page (see figure 3).

FIG. 3: *Continued Fraction*

$$\tan(z) = \cfrac{z}{1 - \cfrac{z^2}{3 - \cfrac{z^2}{5 - \cfrac{z^2}{7 - \cfrac{z^2}{9 - \cfrac{z^2}{11 - \cdots}}}}}}$$

The actual representation of a continued fraction (this one is an approximation of the tangent function) is not practical on the printed page, so by convention a simplified linear notation, as given in the text, is used.

The test is performed by plugging in one of the five values of the angle for z from table 1, evaluating the continued fraction by starting eight fractions down the line and working back, and then comparing the result with the tangent value, also given in table 1. The division test is completed by averaging the results for the infinite product and the continued fraction.

Series 2. The sine and tangent tests successively compare the function value for each of the five angles with the well-known value given in table 1, then add multiples of π to the angles and compare again. The test is repeated with five different multiples.

The arctangent function test, which is derived directly from the chip instruction FPATAN, runs through 50 equally spaced values of the angle θ between 0 and $\pi/2$, determines the tangent and the arctangent, and compares them with the original angle. This test does not measure the absolute accuracy of the arctangent function; it only measures the implementation's consistency with that of the tangent.

Series 3. No such obvious set of values or range of arguments exists for testing the remaining functions: exponential, logarithm, and square root. A procedure analogous to the one used for the arctangent was chosen, except that a step size was defined for the parameter, and then the tests were run 50 times, incrementing the parameter by the step each time.

INTERPRETING RESULTS

Table 2 shows an example of the output produced by the ACCURACY program compiled with the Microsoft C compiler version 4.0. The columns under the heading "ACCURACY" are the rounded negative common logarithms of the computed relative errors. The values approximate the number of decimal digits of accuracy in the computed result; the larger these numbers, the more accurate the computation.

The table includes five columns of accuracy results for each test. For each of the two arithmetic tests, the result represents individual runs. For each function test, the result is an average of five runs; for these function tests, the individual columns have no overall significance but merely serve as a check on any abnormal behavior.

The other result ACCURACY reports is the error rating, which is the average of the differences between the individual accuracy results and a "perfect" accuracy of 17. This number was chosen because it is just out of reach of the precision attainable by the 8-byte long-real data format used by all the tested compilers. The number would be different for evaluating computations on other architectures such as quadruple precision.

The need to limit the measure of accuracy becomes apparent when all the digits produced by a computation happen to be correct. Here the error is 0 and the log of the error is infinite, but the precision of the result is still limited by the number of bits in the number format. Reporting the accuracy as infinite, or as some arbitrarily large value, is not correct because the precision, in fact, is less than that of, say, a quadruple-precision result with a reported accuracy of 25 (accurate to 24 decimal places).

The error rating obtained for any compiler depends somewhat on the detailed choices for the parameters used in the various ACCURACY tests. Changing these parameters can lead to variations in the overall error rating, but the differences in the error ratings between compilers, test by test, should not vary by more than 0.02.

If any test fails by a large factor—an error rating of more than 3—either double precision is not being used or the chip is improperly seated or damaged. (This assumes the test was run with more than one compiler on a PC equipped with a coprocessor.) The chip can function incorrectly but still pass MATHUNIT, a hardware test program supplied with coprocessor chips purchased from Hauppauge.

All compilers were tested on an IBM AT with a 286 running at 8 MHz and a 287 at 5.3 MHz. For comparison, the C and FORTRAN versions of ACCURACY also were run on a VAX 750

TABLE 2: ***Sample ACCURACY Output***

TEST[a]	ACCURACY	ERROR RATING
Series 1		
10 by 10 matrix	16.3 16.1 16.0 15.6 15.3	1.14
Infinite product	16.9 16.7 15.7 16.1 16.1	0.72
Continued fraction	15.2 15.7 17.0 15.9 15.6	1.11
Division average	16.0 16.2 16.4 16.0 15.8	0.91
Series 2		
sin( )	15.3 15.5 15.6 16.0 16.6	1.20
tan( )	14.9 15.4 15.4 15.3 15.7	1.67
atan( )	16.9 17.0 17.0 17.0 16.9	0.02
Series 3		
log( ) and exp( )	17.0 17.0 17.0 16.9 17.0	0.01
sqrt( )	16.2 16.6 16.5 16.5 16.2	0.60
Overall error rating:		0.79

Compiler: Microsoft C 4.00
System: IBM AT with 287
[a] All tests are described in listing ACCURACY.C.

Each execution of the ACCURACY program produces a table similar to this one, giving the accuracy obtained in each iteration of each test as well as the error rating. The accuracy value is roughly equivalent to the number of decimal digits of precision, while the error rating indicates how far the average accuracy is from 17, the theoretical maximum attainable with the 64-bit long real format.

under 4.3 BSD UNIX. The results show that the performances of the better PC compilers are almost identical but fall short of the accuracy available on a minicomputer (see table 3). To determine the reasons requires not only reporting symptoms, but also involves diagnosing the actual numeric algorithms of the hardware and the number-handling procedures of the compiler. The PARANOIA program being developed by IEEE will attempt to do just that. This program will be the subject of another article.

Although the PC compilers do not quite reach the ultimate accuracy that the long-real format can attain, they are surprisingly consistent—only a few showed significantly lower accuracy results. Prospero FORTRAN stands out as somewhat worse than the other FORTRAN compilers, while C Ware's Desmet C is the worst of all the compilers tested. Among the top C compilers, the only error somewhat higher than the norm is the sine test for Borland's Turbo C; this seems to be an anomaly because the other Borland products, Turbo BASIC and Turbo Pascal, are in line with the majority.

The accuracy of FORTRAN programs can be affected by a dangerous implicit syntax that is followed by all the compilers tested here. Although you might have declared IMPLICIT DOUBLE PRECISION A-Z, any expressions involving constants on the right-hand side of an assignment statement are evaluated only to single precision before being assigned to double-precision variables on the left; unless you coerce them by adding a double-precision exponent, such as D0. Unwary programmers can lose a good deal of accuracy this way without knowing it, because no diagnostics are generated. Fortunately, this problem does not occur with C, BASIC, and Pascal.

Oddly enough, all compilers did substantially worse on the tangent than on the sine function, even though the tangent function is based directly on a chip instruction while the sine must be computed from it in a more involved way. The tangent test errors indicate that the tangent calculation could be improved considerably, but that the sine comes out better is puzzling. The development teams of several of the compilers were asked why this might occur, but none had an explanation.

MORE MEASURES

Because ACCURACY contains a well-balanced set of numerical functions reflecting typical use in actual programs, it is also a suitable test for timing compilation and execution (see table 4 for test results). Execution times are for 20 iterations of the ACCURACY program with no output.

The variation in execution times is slight—a ratio of just more than two to one—but it is unexpected. FORTRAN, the erstwhile champion of numerical computation, now barely edges out the

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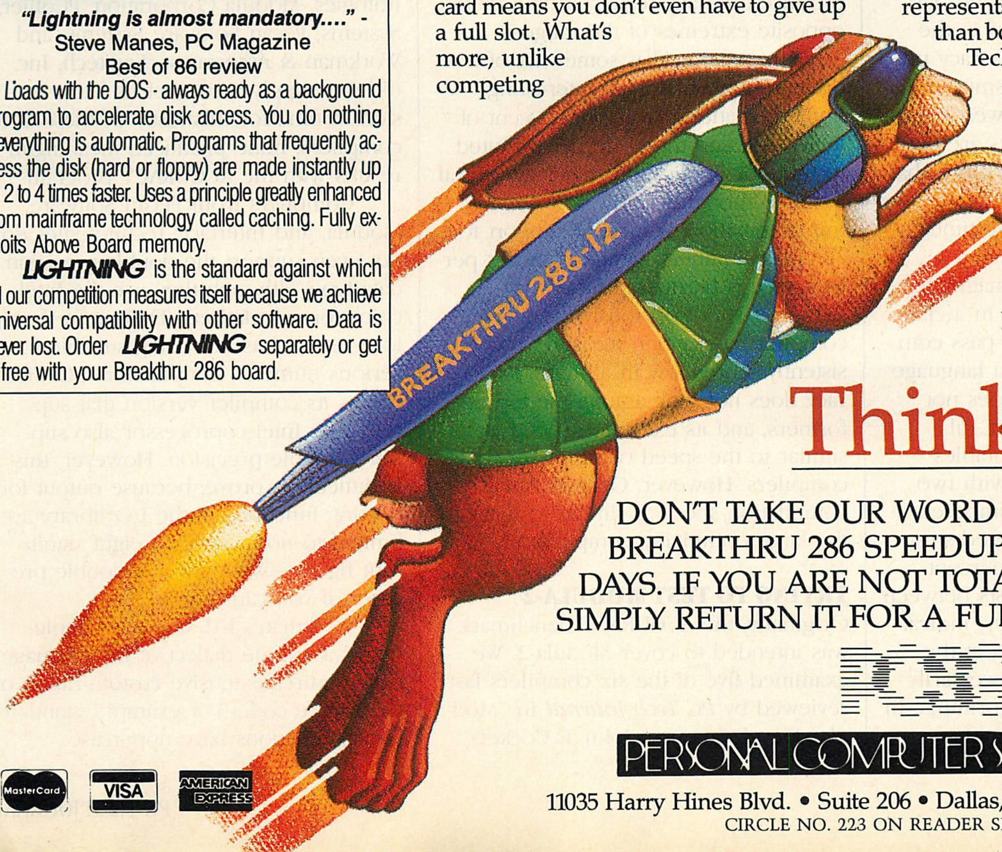

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TABLE 3: *Error Ratings Summary*

	C LANGUAGE						BASIC	
TESTS	**BORLAND**	**C WARE**	**IBM**	**LATTICE**	**MICROSOFT**	**VAX/UNIX**	**BORLAND**	**MICROSOFT**
SERIES 1								
Matrix mult.	1.15	1.15	1.14	1.14	1.14	0.18	1.14	1.05
Infinite product	0.73	0.76	0.72	0.72	0.72	0.09	0.72	0.72
Continued fraction	1.19	2.65	1.11	1.11	1.11	0.63	1.11	1.22
Average	0.96	1.71	0.91	0.91	0.91	0.36	0.92	0.97
SERIES 2								
sin	1.53	2.77	1.20	1.20	1.20	0.54	1.20	1.24
tan	1.66	3.44	1.67	1.67	1.67	0.82	1.67	1.70
atan	0.03	0.04	0.02	0.02	0.02	0.05	0.02	0.02
SERIES 3								
log/exp	0.01	0.01	0.01	0.03	0.01	0.01	0.01	0.01
square root	0.60	0.60	0.60	0.69	0.60	0.13	0.60	0.60
Overall	0.85	1.52	0.79	0.81	0.79	0.30	0.79	0.80

TABLE 4: *Compilation and Execution Times*

	C LANGUAGE					BASIC	
	BORLAND	**C WARE**	**IBM**	**LATTICE**	**MICROSOFT**	**BORLAND**	**MICROSOFT**
Compile/link time	21.0	26.0	75.0	61.0	74.0	4.1	23.0
Execution time	22.6	37.3	22.5	26.9	23.1	44.8	29.5

All times are in seconds.

better C compilers; given the intense competition between Microsoft and Borland, this small edge may not last long. For both FORTRAN and C, the compilers with the worst accuracy performance (Prospero and Desmet, respectively) also have the slowest execution times. Their inaccuracies are evidently not the result of algorithms that trade precision for speed.

The compilation and link times show a wider variation, covering a range of about 2 orders of magnitude. As expected, Turbo Pascal is in a class by itself—it is a simple, one-pass compiler for small programs in a language with a clean syntax, and it does not need a link step. Turbo BASIC, although also producing executables without a linker, must deal with two versions of the language (numbered spaghetti-code and unnumbered structured), and is slower by 70 percent. However, no correlation exists between compiling speed and accuracy, indicating that additional processing at the compilation step does not necessarily produce faster numerical algorithms. In both FORTRAN and C, the two fastest compilers (Lahey and Prospero for FORTRAN, Borland and Desmet for C) produce accuracy results at or near the opposite extremes of the range.

Oregon Pascal is somewhat of a disappointment. It is an interesting implementation that is reminiscent of FORTRAN, and therefore better suited to numeric applications than the typical Pascal. Although it is the sole Pascal implementation to include support for complex numbers, Oregon Pascal's performance is hardly satisfactory. Although it is not obviously the worst compiler by any one measure, it consistently scores low in all tests; its accuracy does not rank among the top performers, and its execution speed is similar to the speed of simple one-pass compilers. However, Oregon Pascal's compilation speed is similar to that of the large optimizing compilers.

TRYING TO TEST MODULA-2

Originally, the ACCURACY benchmark was intended to cover Modula-2. We examined five of the six compilers last reviewed by *PC Tech Journal* in "Modular Developments," John T. Cockerham, March 1987, p. 114. These included compilers from Interface Technologies, Modula Corporation, PCollier Systems, Pecan Software Systems, and Workman & Associates. (Logitech, Inc. did not supply a copy of its latest version in time for this test.) Of these five compilers, none produced meaningful results with the ACCURACY program.

Compilers from Pecan Software, Modula, and Interface Technologies do not even support the double-precision data type, although they use the Intel chips for calculations. They were therefore rejected as not being suitable for serious numeric computation. PCollier claims its compiler version that supports the Intel coprocessor also supports double precision. However, this is difficult to prove, because output formatting functions in the I/O library are limited to no more than eight significant figures. What good is double precision if you can't see it?

Workman's FTL compiler implements a unique dialect of the language that requires extensive customization of the source code. For example, standard library functions have uppercase

FORTRAN						PASCAL	
IBM	LAHEY	MICRO-SOFT	PROS-PERO	RYAN-MCFARLAND	VAX/UNIX	BOR-LAND	OREGON
1.18	1.14	1.14	1.14	1.18	0.18	1.07	1.13
0.72	0.72	0.54	0.72	0.72	0.09	0.77	0.76
1.11	1.11	1.11	1.29	1.11	0.55	1.22	1.11
0.91	0.91	0.83	1.00	0.91	0.32	0.97	0.93
1.20	1.20	1.20	1.52	1.20	0.51	1.17	1.20
1.67	1.67	1.67	2.03	1.67	0.76	1.69	1.74
0.02	0.02	0.20	0.02	0.02	0.05	0.20	0.18
0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
0.60	0.60	0.60	0.60	0.60	0.13	0.65	0.60
0.80	0.79	0.78	0.90	0.80	0.28	0.82	0.83

The error ratings for all tested compilers are remarkably close; however, no error rating can match the accuracy of a VAX minicomputer that is running UNIX.

FORTRAN					PASCAL	
IBM	LAHEY	MICRO-SOFT	PROS-PERO	RYAN-MCFARLAND	BOR-LAND	OREGON
91.0	23.0	92.0	58.0	103.0	2.8	88.0
21.4	20.3	19.8	23.4	20.5	88.0	37.5

The compilation times include linking with Microsoft LINK Version 3.55, where possible. Execution times are for 20 iterations of ACCURACY with no output.

names, but most implementations use lowercase names (Modula-2, like C, is case-sensitive). The library omits type-conversion functions, such as those from integer to real, but the compiler generates implicit conversions in assignment statements. This is convenient for writing numeric programs, but highly nonstandard in a language as strongly typed as Modula-2.

The FTL compiler's nonstandard syntax, along with its missing documentation, poor error messages, and outright compiler bugs made it impossible to create a version of the ACCURACY program that would compile cleanly with the FTL compiler.

The PC implementations of Modula-2 should not reflect on the language itself. Modula-2 on the Sun 3 is a respectable compiler, but the PC Modula-2 compilers are, for the most part, poorly designed and hostile. Few of these compilers provide adequate information on how to compile source code in ASCII; furthermore, most of them assume that the user will write all programs in Modula-2's integrated environment.

However, even apart from its PC implementations, Modula-2 is poorly designed to support numeric computation. It has no function for taking the absolute value of a real number, only of an integer. Logitech (whose compiler was not examined) claims that its **abs()** function also operates on cardinals, or unsigned integers; this is reassuring but hardly useful. A function RABS() for real numbers is simple to define, but a serious language should already include it. Another inconvenience in most implementations is the presence of two functions to convert from integer to real values, **float()** for cardinals and **real()** for signed integers.

TOP PERFORMERS

The programmer looking for acceptable performance in a numerically intensive program could choose any of eight or nine C or FORTRAN compilers. These top performers show little differences in execution speed or double-precision accuracy. Choices should be based on language preference or on factors such as quality of documentation, ease of use, and technical support.

The IBM FORTRAN compiler used in this evaluation is derived from an earlier version of Ryan-McFarland FORTRAN, and IBM C is derived from Microsoft C version 3.0. Not surprisingly, the accuracy results of the IBM compilers are identical, and timing results very similar, to the results of the current releases of the compilers from which they are derived. IBM has subsequently announced that these compilers are are being replaced with FORTRAN/2 and C/2 that will run under both DOS and OS/2.

The integrated BASIC environments produce programs with accuracy as good as any PC product, but with the sluggish performance typical of one-pass, nonoptimizing compilers. Another disadvantage is that structured BASIC has not yet settled down in terms of syntax or supported data types. Microsoft's QuickBASIC and Borland's Turbo BASIC are incompatible in their definitions of constants and in their rules for variable scoping. Turbo BASIC allows only short integer constants—a serious drawback in numeric work. But if BASIC must be the choice, QuickBASIC is better-suited to serious programming because of its superior syntax, automatic segmentation of large programs, support for separate compilation and linking, and faster programs (than those of Turbo BASIC).

Neither of the two Pascal implementations evaluated here is top-notch. Oregon Pascal has interesting support for numeric computation, but it suffers from lackluster performance in speed as well as accuracy. The drawbacks of Borland's Turbo Pascal include its limited program and data size and lack of separate compilation, all of which are too confining for major computational efforts. It will be interesting to see how the next version of Turbo Pascal will address these limitations.

As far as Pascal's derivative, Modula-2, is concerned, not only does the design of the language make it difficult to use in numeric applications, but the implementations available on the PC make it impossible.

Finally, the tests show that for heavy-duty number-crunching at highest-level accuracy, the PC is still no match for larger hardware.

Borland International, Inc.
4585 Scotts Valley Drive
Scotts Valley, CA 95066-9987
800/255-8008; 800/742-1133
Turbo BASIC 1.1, Turbo Pascal 3.01A, Turbo C 1.0
CIRCLE 352 ON READER SERVICE CARD

C Ware Corporation
945 Spring Street
Suite 14
Paso Robles, CA 93446
805/239-4620
DeSmet C 2.6
CIRCLE 353 ON READER SERVICE CARD

IBM Corporation
900 King Street
Rye Brook, NY 10573
800/426-2468
IBM C 1.00, IBM FORTRAN 1.01
CIRCLE 354 ON READER SERVICE CARD

Lahey Computer Systems, Inc.
P.O. Box 6091
Incline Village, NV 89450-6091
702/831-2500
Lahey F77L FORTRAN 2.2
CIRCLE 355 ON READER SERVICE CARD

Lattice, Inc.
2500 S. Highland Avenue
Tombard, IL 60148
800/533-3577; 312/916-1600
Lattice C 3.2
CIRCLE 356 ON READER SERVICE CARD

Microsoft Corporation
16011 N.E. 36th Way
P.O. Box 97017
Redmond, WA 98073-9717
800/426-9400; 206/882-8080
Microsoft QuickBASIC 3.00, Microsoft C 4.00, Microsoft FORTRAN 4.00A
CIRCLE 357 ON READER SERVICE CARD

Oregon Software, Inc.
6915 S.W. Macadam Avenue
Suite 200
Portland, OR 97219
800/367-2202; 503/245-2202
Oregon Pascal-2 2.2A
CIRCLE 358 ON READER SERVICE CARD

Prospero Software Limited
U.S. Distributor: Software Consulting Services
3162 Bath Pike
Nazareth, PA 18064
215/837-8484
Pro FORTRAN 1.141
CIRCLE 359 ON READER SERVICE CARD

Ryan-McFarland Corporation
609 Deep Valley Drive
Rolling Hills Estates, CA 90274
213/541-4828
RM/FORTRAN 2.11
CIRCLE 360 ON READER SERVICE CARD

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LISTING 1: ACCURACY.C

```
/* ACCURACY.C: double precision math accuracy tester, v 1.7
 * The strings COMPIL and MACHIN should be set for each system.
 * Format is not ideal C style, because it is meant to be
 *  easily convertible among several programming languages.
*/

#define  NOTANSI            0  /* old or nonconforming compilers */

#if NOTANSI
#else
#define  LINT_ARGS          1  /* arg chk in Microsoft C headers */
#define  NO_EXT_KEYS        1  /* no non-ANSI keywords in MS C   */
#define  __STDC__           1  /* ANSI C in Turbo C headers      */
#endif  /* NOTANSI */

#include <stdio.h>
#include <math.h>

 char *COMPIL  = "Microsoft C 4.0" ;
 char *MACHIN  = "IBM PC/AT-287"  ;
#define  MINERR        1.0E-17    /* for 64 bit reals           */
#define  LOGMIN       17.0        /* -LOG10(MINERR)             */

#define  N            10          /* size of matrix             */
#define  Y             1.0        /* const element of matrix */
#define  STEP          0.2        /* for function tests         */
#define  ITERTRIG      5          /* for trig tests             */
#define  ITER         20          /* for other function tests */

#if NOTANSI
#define  LOG10E       0.434294481903251828
#define  PI           3.141592653589793238
#define  PIO2         1.570796326794896619
#define  ROOT2        1.414213562373095049
#define  ROOT3        1.732050807568877293
#define  SQRTO2       0.707106781186547524
#else
#ifndef  PI
#define  PI           3.14159265358979323846
#endif      /* PI */
#define  PIO2         1.57079632679489661923
#define  LOG10E       0.43429448190325182765
#define  ROOT2        1.4142135623730950488
#define  ROOT3        1.7320508075688772935
#define  SQRTO2       0.7071067811865475244
#endif  /* NOTANSI */

#define  osgn(n)      ( (n==2*(n/2)) ? 1 : -1 )
                       /* -1 if n int & odd */
double  a[N][N], b[N][N], c[N][N], sum, X ;
int     i, j, k, l, m, ntest;
double  th[6], val[6], err[6], logerr[6], diverr[6], funct[6] ;
double  testerr[11], toterr;
double  xx, zz, quot ;
double  a0, a1, d0, d1, frac ;
double  p, p2 ;

void filla()
{
int     i, j;
   for (i = 0; i < N ; i++)
       for (j = 0 ; j < N ; j++)
           if (i != j) a[i][j] = Y ;
              else    a[i][j] = X + Y ;
}

void fillb()
{
int     i, j ;
double  f, d ;
   f = X + N*Y ;
   d = 1.0 / (X * f)   ;
   for (i = 0 ; i < N ; i++)
       for (j = 0 ; j < N ; j++)
          if (i != j)     b[i][j] =  -Y * d ;
             else         b[i][j] =  (-Y + f) * d ;
}

void fillc()
```

```
{
int     i, j;
   for (i = 0 ; i < N ; i++)
       for (j = 0 ; j < N ; j++)
           c[i][j] = 0.0;
}

void matmult()
{
int     i, j, k;
   for (i = 0 ; i < N ; i++)
       for (j = 0 ; j < N ; j++)
           {
           sum = 0.0;
           for (k = 0 ; k < N ; k++)
               sum +=  a[i][k] * b[k][j];
           c[i][j] = sum;
           }
}

void sumit()
{
int     i, j;
   sum = 0.0;
   for (i = 0 ; i < N ; i++)  c[i][i] -= 1.0 ;
   for (i = 0 ; i < N ; i++)
       for (j = 0 ; j < N ; j++)
           sum += fabs(c[i][j]) ;
}

void header()
{
   printf("ACCURACY: double precision reals tester: ");
   printf("%s; %s.\n", COMPIL, MACHIN) ;
   printf("          V 1.7 (c) 1987, Jim Roberts.\n");
   printf("Test 1 checks multiplication and addition, ");
   printf("then division and subtraction.\n");
   printf("Test 2 measures the accuracy of the trig functions ");
   printf("sin(), tan(), and atan().\n");
   printf("Test 3 finds the truncation error in some ");
   printf("exponential and sqrt identities.\n");
   printf("ACCURACY is the rounded negative log of error.  ");
   printf("Program may exit abnormally.\n");
   printf("NOTE: an increase of 1 in the rating means ");
   printf("a factor of TEN less accurate.\n");
   printf("Interpretation  <0.0 - 0.5 => Excellent     ");
   printf("1.0 - 1.5 => Fair\n");
   printf("  of RATING:     0.5 - 1.0 => Good          ");
   printf("1.5 <     => Poor\n");
   printf("\n") ;
   printf("     TESTS                         ACCURACY          ");
   printf("RATING          \n");
}

void arith()
{
/*TEST 1: well-conditioned combinatorial matrix times its inverse.*/
   zz = 0.30 ;   /*factor used to control decrease of condition   */
   for (l=0;l<5;l++)
      {
      xx = (double)(zz*(2-l)) ;
      X = pow(10.0,xx) ;  /* slowly decreases condition */
      filla() ; fillb() ; fillc() ;
      matmult() ; sumit() ;
      err[l] = sum/((double)(N*N));
                  /* error is average absolute per element */
      if (err[l] > MINERR) logerr[l] = -log(err[l]) * LOG10E;
                        else logerr[l] = LOGMIN;
      testerr[1] += LOGMIN - logerr[l] ;
      }
   testerr[1] /= 5.0 ;

   printf("#1a: 10x10 matrix       ");
   for (l=0;l<5;l++) printf("% 5.1f",logerr[l]) ;
   printf("   %6.2f\n",testerr[1]);

/* TEST 2: infinite product and continued fraction */

/* infinite product for 1-delt: run in reverse to test division */
   sum = 0.0 ;
   for (l=0;l<5;l++)
```

```
    {
    xx = (double)(-l) / 4.0;
    zz = pow(10.0, xx-2.0);
                /* increases number of factors for convergence */
    xx = 1.0 - zz ; /* lose about 2 significant figures here    */
/*
 *    The following formula for the number of factors is designed
 *    to give sufficient accuracy, while avoiding underflow
 *    in the powers of xx.  It gives a more uniform computation
 *    from compiler to compiler.
 */
    m  = 13+l ;
    quot = 1.0 ;
    for (k=1;k<=m;k++) {
       quot /= (1.0 + xx) ;
       xx *= xx ;
       }
    err[l] = fabs(1.0 - quot/zz)*0.01 ;
    /* factor of 0.01 compensates for cancellation error above */
    if (err[l] > MINERR) diverr[l] = -log(err[l]) * LOG10E ;
                   else diverr[l] = LOGMIN ;
    sum += LOGMIN - diverr[l] ;
    logerr[l] = diverr[l] ;        /* needed for later average */
    }
  sum /= 5.0 ;

  printf("#1 : infinite product   ");
  for (i=0;i<5;i++) printf("% 5.1f",diverr[i]) ;
  printf("   %6.2f\n",sum);
/*
 * continued fraction for tan() compared to actual values
 * for five angles: this is a test of division and subtraction,
 * not of the tangent.
 */
    th[0] = PI/12.0 ;
    th[1] = PI/6.0 ;
    th[2] = PI/4.0 ;
    th[3] = PI/3.0 ;
    th[4] = 5.0*PI/12.0 ;
    val[0] = 2.0 - ROOT3 ;
    val[1] = 1.0 / ROOT3 ;
    val[2] = 1.0         ;
    val[3] = ROOT3 ;
    val[4] = 2.0 + ROOT3 ;
    sum = 0.0 ;
    m = 8 ;    /* number of iterations, gives sufficient accuracy */
    for (l=0;l<5;l++)
      {
      a0 = 2.0 * m + 1.0 ;
      p2 = th[l] ;
      p  = p2*p2 ;
      d0 = a0 - p / (a0 + 2.0) ;

    for (k=0;k<m;k++)
      {
      a1 = a0 - 2.0 ;
      d1 = a1 - p / d0 ;
      a0 = a1 ;
      d0 = d1 ;
      }
    frac = p2 / d0 ;
    funct[l] = frac ;
    }

for (l=0;l<5;l++)
   {
   err[l] = fabs(1.0 - val[l]/funct[l]) ;
   if (err[l] > MINERR) diverr[l] = -log(err[l]) * LOG10E;
                  else diverr[l] = LOGMIN ;
   sum += LOGMIN - diverr[l] ;
   }
sum /= 5.0 ;

printf("#1 : continued fraction ");
for (i=0;i<5;i++) printf("% 5.1f",diverr[i]) ;
printf("   %6.2f\n",sum);

printf("#1b: division average   ");
for(i=0;i<5;i++) {
   logerr[i] = 0.5 * (logerr[i] + diverr[i]) ;
```

```
        testerr[2] += LOGMIN - logerr[i] ;
        }
    testerr[2] /= 5.0 ;
    for (i=0;i<5;i++) printf("% 5.1f",logerr[i]) ;
    printf("   %6.2f\n",testerr[2]);
}

void trig()
/*TEST 2: first, truncation in some sine identities */
{
    for (l=0;l<5;l++) logerr[l] = 0.0 ;
    for (j=0;j < ITERTRIG;j++)
        {
        th[0] = PI/12.0 + j*PI ;
        th[1] = PI/6.0 + j*PI ;
        th[2] = PI/4.0 + j*PI ;
        th[3] = PI/3.0 + j*PI ;
        th[4] = 5.0*PI/12.0 + j*PI ;
        val[0] = osgn(j)*ROOT2*(ROOT3-1.0)*0.25 ;
        val[1] = osgn(j)*0.5 ;
        val[2] = osgn(j)*SQRTO2 ;
        val[3] = osgn(j)*0.5*ROOT3 ;
        val[4] = osgn(j)*ROOT2*(ROOT3+1)*0.25 ;
        for (l=0;l<5;l++) funct[l] = sin(th[l]) ;
        for (l=0;l<5;l++)
            {
            err[l] = fabs(1.0 - val[l]/funct[l]) ;
            if (err[l] > MINERR) logerr[l] -= log(err[l]) * LOG10E;
                        else logerr[l] += LOGMIN ;
            }
        }
    for (l=0;l<5;l++) logerr[l] /= (double)ITERTRIG ;
    for (l=0;l<5;l++) testerr[3] += LOGMIN - logerr[l] ;
    testerr[3] /= 5.0 ;

    printf("#2a: sin()              ");
    for (i=0;i<5;i++) printf("% 5.1f",logerr[i]) ;
    printf("   %6.2f\n",testerr[3]);

/* compare tan() with exact values */
    for (l=0;l<5;l++) logerr[l] = 0.0 ;
    for (j=0;j < ITERTRIG;j++)
        {
        th[0] = PI/12.0 + j*PI ;
        th[1] = PI/6.0 + j*PI ;
        th[2] = PI/4.0 + j*PI ;
        th[3] = PI/3.0 + j*PI ;
        th[4] = 5.0*PI/12.0 + j*PI ;
        val[0] = 2.0 - ROOT3 ;
        val[1] = 1.0 / ROOT3 ;
        val[2] = 1.0         ;
        val[3] = ROOT3 ;
        val[4] = 2.0 + ROOT3 ;
        for (l=0;l<5;l++) funct[l] = tan(th[l]) ;
        for (l=0;l<5;l++)
            {
            err[l] = fabs(1.0 - val[l]/funct[l]) ;
            if (err[l] > MINERR) logerr[l] -= log(err[l]) * LOG10E;
                        else logerr[l] += LOGMIN ;
            }
        }

    for (l=0;l<5;l++) logerr[l] /= (double)ITERTRIG  ;
    for (l=0;l<5;l++) testerr[4] += LOGMIN - logerr[l] ;
    testerr[4] /= 5.0 ;

    printf("#2b: tan()              ");
    for (i=0;i<5;i++) printf("% 5.1f",logerr[i]) ;
    printf("   %6.2f\n",testerr[4]);
/* compare atan() with tan() for consistency */
    for (l=0;l<5;l++) logerr[l] = 0.0 ;
    for (j=0;j < ITER;j++)
        {
        for (l=0;l<5;l++) th[l] = (5*j+l+1)*PIO2/(5*ITER+1) ;
        for (l=0;l<5;l++) val[l] = tan(th[l]) ;
        for (l=0;l<5;l++) funct[l] = atan(val[l]) ;
        for (l=0;l<5;l++)
            {
            err[l] = fabs(1.0 - th[l]/funct[l]) ;
```

```
        if (err[l] > MINERR) logerr[l] -= log(err[l]) * LOG10E;
                     else logerr[l] += LOGMIN ;
        }
    }
  for (l=0;l<5;l++) logerr[l] /= (double)ITER ;
  for (l=0;l<5;l++) testerr[5] += LOGMIN - logerr[l] ;
  testerr[5] /= 5.0 ;

  printf("#2c: atan()              ");
  for (i=0;i<5;i++) printf("% 5.1f",logerr[i]) ;
  printf("   %6.2f\n",testerr[5]);

}

/* TEST 3: log() against exp() for consistency */

void transc()
{
  for (l=0;l<5;l++) logerr[l] = 0.0 ;
  for (j=0;j<ITER;j++)
    {
      for (l=0;l<5;l++)  th[l] = (5*j+l+1)*STEP ;
      for (l=0;l<5;l++)  val[l] = exp(th[l]) ;
      for (l=0;l<5;l++)  funct[l] = log(val[l]) ;
      for (l=0;l<5;l++)
        {
         err[l] = fabs(1.0 - th[l]/funct[l]) ;  /* unnormalized */
         if (err[l] > MINERR) logerr[l] -= log(err[l]) * LOG10E;
                      else logerr[l] += LOGMIN;
        }
    }
  for (l=0;l<5;l++) logerr[l] /= (double)ITER ;
  for (l=0;l<5;l++) testerr[6] += LOGMIN - logerr[l] ;
  testerr[6] /= 5.0 ;

  printf("#3a: log() & exp()      ") ;
  for(i=0;i<5;i++) printf("% 5.1f",logerr[i]);
  printf("   %6.2f\n",testerr[6]);

}
```

```
/* sqrt() identities */
void roots()
{
  for (l=0;l<5;l++) logerr[l] = 0.0 ;
  for (j=0;j<ITER;j++)
    {
      for (l=0;l<5;l++) th[l] = (5*j+l+1)*STEP ;
      for (l=0;l<5;l++) val[l] = sqrt(th[l]) ;
      for (l=0;l<5;l++) funct[l] = val[l]*val[l] ;
      for (l=0;l<5;l++)
        {
         err[l] = fabs(1.0 - th[l]/funct[l]) ;   /* unnormalized */
         if (err[l] > MINERR) logerr[l] -= log(err[l]) * LOG10E;
                     else logerr[l] += LOGMIN;
        }
    }
  for (l=0;l<5;l++) logerr[l] /= (double)ITER ;
  for (l=0;l<5;l++) testerr[7] += LOGMIN - logerr[l] ;
  testerr[7] /= 5.0 ;

  printf("#3b: sqrt()           ") ;
  for(i=0;i<5;i++) printf("% 5.1f",logerr[i]);
  printf("   %6.2f\n",testerr[7]);
}

main()
{
  header();
  for (i=0;i<10;i++) testerr[i] = 0.0 ;
  arith();
  trig();
  transc();
  roots();
  ntest = 7 ;
  toterr = 0.0 ;
  for (i=1;i<=ntest;i++) toterr += testerr[i] ;
  toterr /= (double)ntest ;
  printf("Overall rating: %6.2f\n",toterr) ;
  return(0) ;
}
```

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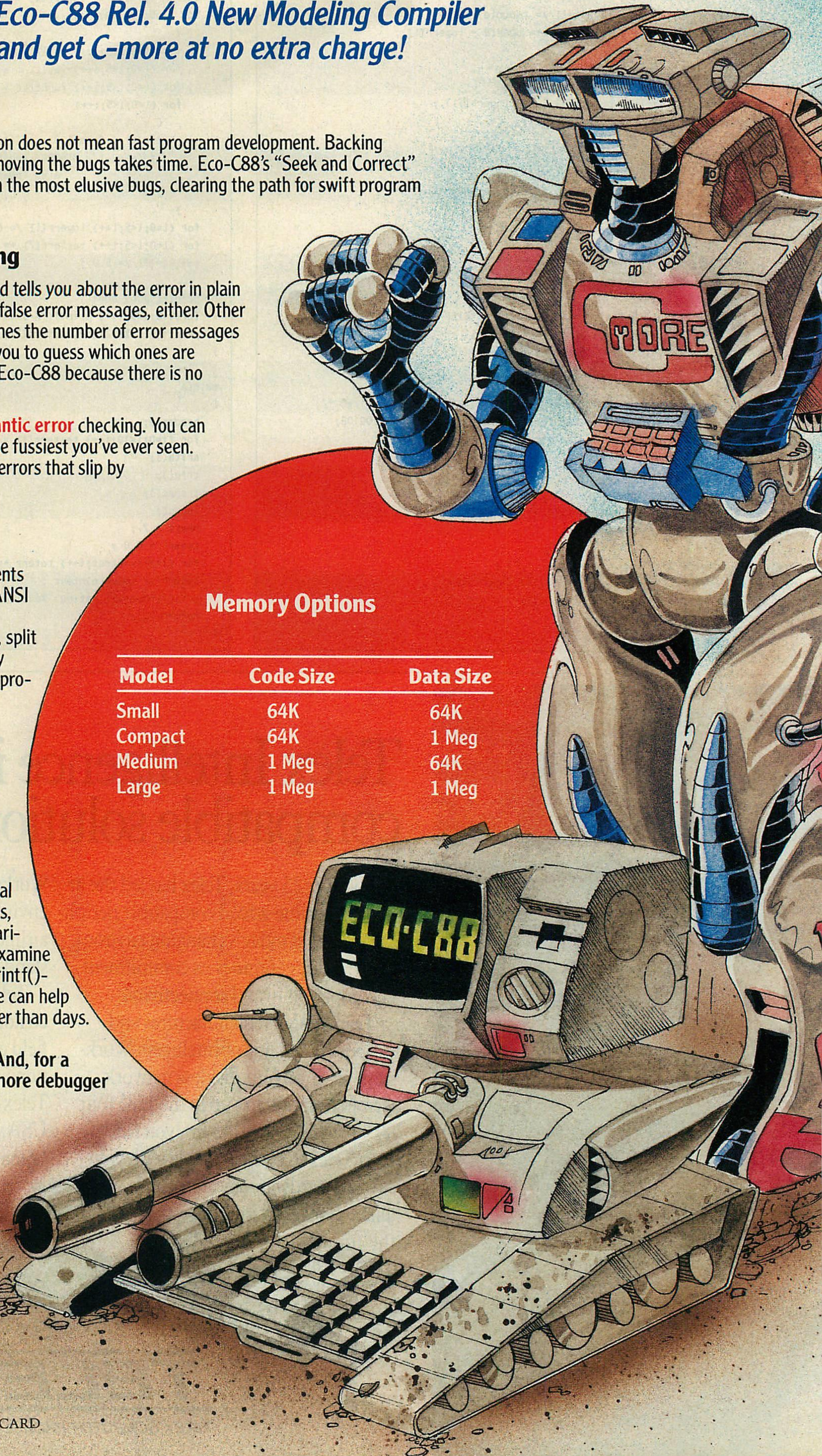

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PRODUCT WATCH

Reviews and Updates

QUAID ANALYZER
Quaid Software Limited

REFEREE
Persoft, Inc.

DS OPTIMIZE
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QUAID ANALYZER

Quaid Software Limited
45 Charles Street East, 3rd Floor
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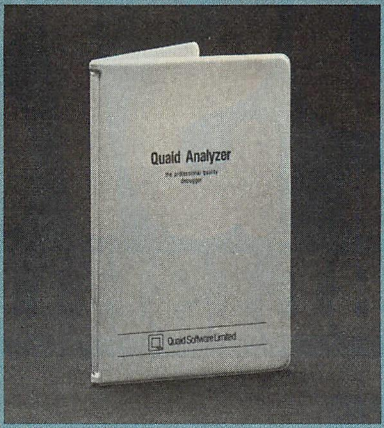
416/961-8243

PRICE: $99



CIRCLE 342 ON READER SERVICE CARD

The Quaid Analyzer is a memory-resident tracing, debugging, and disassembly tool that has some of the features of a hardware debugger at a fraction of the cost. Unlike standard software debuggers such as DOS DEBUG or Microsoft's SYMDEB and CodeView, the Quaid Analyzer allows the tracing of execution and trapping of interrupts in DOS, BIOS, device drivers, and the system bootstrap routine. It is advertised by Quaid as the software used in developing CopyWrite, a program that copes with copy-protected software. Not for beginners, it requires a familiarity with assembly language and the workings of the operating system. System requirements are an IBM PC, PC/AT, or compatible with at least 100KB of memory running DOS 2.0 or later versions.

The Quaid Analyzer is installed by a command at the DOS prompt, then activated by pressing the Shift-PrtSc key. Once installed, it cannot be removed except by rebooting the system. The command structure is menu-driven, and it uses function keys and the escape key to navigate among five main display types: the main menu, vector display, trace display, program display, and user display.

From the main menu, the user can control the appearance and behavior of the analyzer and set breakpoints on I/O port activity. One option allows moving the analyzer code to the top of memory and performing a warm boot that leaves it intact, allowing the tracing of the system-initialization process.

The vector display shows the interrupt table and allows the setting of breakpoints on the occurrence of particular interrupts. The breakpoint can be set to display register contents before or after the interrupt, or both. For the DOS interrupt 21H, the breakpoint can be specified to occur only when a program is loaded, so that DOS functions issued by COMMAND.COM are not trapped. For the BIOS disk interrupt 13H, the user may choose to trap only write attempts. This is useful in detecting Trojan Horse programs that attempt to trash a hard disk, but is not a reliable test unless interrupt 26H (absolute disk write) is also trapped.

The trace display shows information at each interrupt breakpoint selected on the vector display. For each interrupt, the following information is shown at minimum: the interrupt number, text explaining the interrupt, and the AX register. For interrupts 21H and 10H (BIOS video), the display shows the name of the function identified by the code in AH and the meanings of the parameters in the other registers.

The program display shows the processor registers and the disassembled instructions currently being executed. The user may change any of the registers or flags, and search the data segment for hexadecimal or text data.

From the program display, the user can switch to the reference display, which shows references to the instruction at which the cursor is pointing within the instruction display. References include short jumps, near jumps, and calls within the current code segment, and complete segment:offset pairs anywhere in memory. This presents a list of all possible paths to the current instruction.

The memory display allows viewing and changing data in memory and setting breakpoints on the alteration of a memory location. Data can be displayed in a variety of formats, such as disassembled instructions, hexadecimal data (with high- and low-order bytes both reversed and not reversed), decimal, or ASCII data. Another option is to display information about the DOS memory allocation chain.

Finally, the user display shows the output of the program begin traced. The analyzer only works in text modes; that is, video mode 7 on a monochrome adapter, or modes 2 or 3 on CGA or EGA adapters. It cannot be used to trace programs that operate on graphics modes, either on the same monitor or on a dual-monitor system. This limitation, not spelled out in the documentation, was supplied by Quaid's technical support.

The Quaid Analyzer was tested on a PC/XT both with and without a Microsoft Mach 10 (an 8086 accelerator board running at 9.5 MHz), and on a PC Designs AT-compatible running at 8 MHz. For the most part, it operated satisfactorily, but had some difficulties interacting with programs that take over the keyboard interrupt. For example, when running with Ashton-Tate's MultiMate word processor, it took several attempts to exit the analyzer and return to the word processor. Also, when quitting an interrupt trace within DOS or BIOS, the system sometimes hangs up, indicating that the analyzer is not quite

bulletproof when extricating itself from whatever it is tracing. This condition usually can be avoided by cancelling interrupt tracing only when no interrupts are being serviced.

For the Quaid Analyzer, the primary investment has been made in assuring ease of use, rather than in providing glossy documentation. The manual is a bit cryptic, but serviceable. It consists of 43 pages (5.5-by-8.5 inches), printed on both sides. The unbound pages are intended to be added to a three-ring binder. The typography is uneven, and could use the help of section numbers or indentations to set off the various sections one from another. If the manual's organization is occasionally unclear, the product makes up for it with its ease of use.

The manual does provide a complete explanation of how to use the product. It explains the procedure for tracing the system bootstrap routine, and it gives advice for tracing the more troublesome interrupts such as 1CH (user timer interrupt) and the asynchronous hardware interrupts (8 to 0FH, and 70H through 77H). It contains a warning against tracing interrupts and ports with rigid timing dependencies; for example, interrupt 14H (BIOS asynchronous communications interrupt) when incoming data is arriving, and monitoring a video adapter port for the occurrence of a horizontal retrace cycle. Another example—unfortunately, not mentioned in the manual—is interrupt 2AH, the MS-NET session layer interrupt, whose tracing locks up the system. Monitoring hardware-related processes like these, of course, is beyond the scope of a software debugger and calls for hardware tools such as the Atron PC-Probe, Periscope III, or Intel In-Circuit Emulator.

At $99, the Quaid Analyzer is an excellent value considering what it does. Unlike many other system-level analysis and debugging tools, the Quaid Analyzer is extremely easy to learn and to use. It will be especially useful for detecting Trojan Horse public domain programs acquired from bulletin boards. It is highly recommended for users who want to trace DOS or BIOS, need to reverse-engineer some other system-level software, or are just curious about how DOS and BIOS actually work. In light of the fact that IBM does not publish BIOS listings for the PS/2 machines, the Quaid Analyzer is an ideal tool for exploring the inner workings of the PS/2 BIOS.

—BEN MYERS

DS OPTIMIZE

Design Software Inc.
1275 W. Roosevelt Rd.
Suite #104
West Chicago, IL 60185
800/231-3088; 312/231-4540

PRICE: $69.95

CIRCLE 343 ON READER SERVICE CARD

Hard-disk optimizers, essential tools for maximizing hardware resources, speed up disk accesses by modifying the physical structure and location of files on the disk so that a file can be accessed with minimal movement of the read/write head. Design Software's DS Optimize version 1.10b not only performs this modification, but also aspires to be a general-purpose, hard-disk organizer.

Optimization is important to compensate for the fragmentation of files that can occur when DOS reads and writes information to the disk. Files are stored on disks in units called clusters, which can be set to 1,024, 2,048, 4,096, and 8,192 bytes when the disk is formatted. DOS uses as many clusters as needed to store a file. For example, on a disk with 2,048-byte clusters, a 40,000-byte file will occupy 20 clusters.

When DOS writes a file to disk, it starts at the beginning of the disk's data area, and empty clusters are filled in wherever they are found. When a disk is new and files are first being copied to it, files are stored in logically consecutive clusters. Thus, the head movement that is required to read these contiguous files is minimal. With continued disk use and repeated copying, erasing, and modifying of data, however, files can become fragmented or noncontiguous—that is, their clusters are scattered in various locations on the disk. The more a file is fragmented, the longer it will take to read it from the disk because of the time that is required for the disk's read/write head to seek out the scattered clusters.

Disk optimization consists of reorganizing the information on a disk so that all files are contiguous. This is done by copying files from their old, fragmented locations to new, contiguous ones, using an empty disk area for temporary storage during processing. Because all disk optimization programs work in essentially the same manner, they must be evaluated primarily on their flexibility and ease of use.

DS Optimize version 1.10b offers three optimization options: Test, Protected, and Fast. Test optimize simply checks for compatibility between a disk and the program. Protected optimize moves a single cluster at a time, and can be interrupted (by the user or a power failure) without data loss. Fast optimize works faster by moving multiple clusters at once, but cannot be interrupted without loss of some data. (If you like to drive without a seatbelt, you'll love Fast optimize!)

Either the entire disk, or just specified subdirectories or files, can be optimized. Files can be excluded from the process by attribute or by name. In addition, DS Optimize offers a number of general disk-management functions, such as copying, moving, sorting, and renaming files; creating and removing directories; manipulating certain file attributes; and finding files.

DS Optimize allows one to specify the most-read and most-written subdirectories and files. It will place the most-read file(s) at the beginning of the disk's data area, where head movement between the file allocation table (FAT) and the data area is minimal, and the most-written file(s) at the end of allocated data space, minimizing the head movement needed to access new clusters. Unfortunately, the most-read files are often the most-written as well. In any event, these options do not seem to make any measurable difference in disk speed. When WordPerfect was chosen as the most-read file, DS Optimize did move it from its original (unfragmented) position in the middle of the disk to the beginning of the data area, but load time remained unchanged (2.7 seconds before and after optimization).

The user interface is good, but not great. The bottom two lines of the screen are devoted to a Lotus-style menu, with choices on the first line and descriptions on the second. Selections are made with a moving highlight bar or a single keystroke. The remain-

der of the screen displays various information depending on what the program is doing at the moment: subdirectory tree, file listings, fragmentation chart, progress of optimization, and so on. This information is complete and clearly presented. Screen colors can be changed from within the program. Different program setups (colors, optimization options, etc.) can be saved to disk for quick recall.

DS Optimize provides a visual chart of fragmentation at the disk, subdirectory, or file level. This display's maximum resolution depends on disk size, with lower resolution for larger disks. For example, on a 10MB disk, the resolution is 5 clusters, while on a 32MB disk it is 28 clusters. On larger disks, the low resolution limits the usefulness of this display because it will not reveal fragmentation below the level of the display resolution. What is needed is a single number that summarizes the overall state of file fragmentation. Another useful addition would be a file touch-up feature that automatically optimizes only fragmented files across the entire disk, while it does nothing to unfragmented files.

DS Optimize requires a minimum of 256KB of memory, and will use more if it is available. It can handle a maximum of 5,000 files on a disk and 2,000 files per subdirectory. In theory, it can be used on any size disk or partition as long as these limits are not exceeded; however, it was not tested on disks larger than 42MB.

Benchmarking disk optimization programs is difficult because both the speed of the optimization process and the resulting improvements in disk speed depend on the initial amount of fragmentation on the disk. Using the protected option, DS Optimize took 20 minutes to optimize all files (about 900 files totalling 20MB) on a 42MB, AT-class disk. This time is not strikingly different from those of other available optimization programs.

One disappointing feature is that DS Optimize cannot be run from the DOS command line. This precludes the most convenient way for disk optimization to be performed—from a batch file that first runs your tape backup program and then runs the optimizer, perhaps while you are at lunch or late at night when no users are on the network. Yes, you should make a backup before optimizing. Optimization is a disk-intensive process, and if your disk is destined to crash, optimization (with any optimizer) could well bring it on.

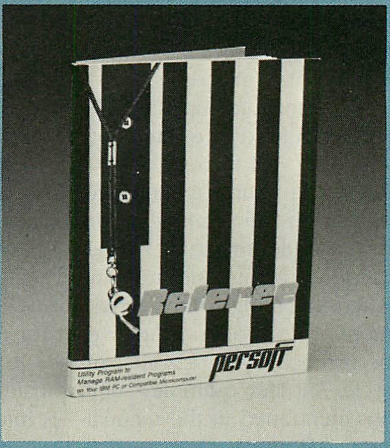
If you want a lean, fast program that does only optimization, DS Optimize may not be the one for you. In addition to disk optimization (which, within the limits of the shortcomings mentioned previously, it does quite well), DS Optimize tries to be a general-purpose disk manager. Other programs do file copying, directory sorting, moving, and so on, better and faster. However, if you like the one-program-does-everything approach, DS Optimize would be a good choice.

—PETER G. AITKEN

REFEREE

Persoft, Inc.
465 Science Drive
Madison, WI 53711
608/273-6000

PRICE: $69.95



CIRCLE 343 ON READER SERVICE CARD

Referee, from Persoft, Inc., is a set of programs that manage terminate-and-stay-resident (TSR) programs. TSRs offer very useful functions at the touch of a key; for example, by pressing Ctrl-Alt while in a text editor, a user can pop up a calculator or a phone dialer without leaving the original application. However, the price to pay for using TSRs is steep; these products eat up system memory quickly, and they often get tangled with one another and with non-TSR applications. This tug-of-war for control of the machine, unfortunately, can lead to keyboard lockups, data loss, and other quite unpleasant situations.

The Referee package helps manage the use of TSRs in several ways. It can turn TSRs on and off without unloading them from memory, or it can remove them from memory without forcing a reboot of the machine. To conserve memory, Referee can automatically en-

able or disable predefined sets of TSRs when specific applications are loaded. Moreover, it can report on the status of TSRs: which are loaded, which are active, and how much memory each uses. The package requires an IBM PC, PC/XT, PC/AT, or compatible with a minimum capacity of 128KB.

Installation is accomplished by simply copying all files on the master diskette to the hard disk or to a work diskette. The two main programs within Referee are REFWATCH, the RAM-resident monitoring program, and REFEREE, the menu-driven control and status program. An additional TSR, SIDELINE, is provided to allow access to Sideline Referee from within any application. REFWATCH must be loaded from the directory in which Referee programs reside, and it must be loaded before all programs that are to be controlled by the REFEREE program, so that their locations and states can be known to Referee. The required TSR, REFWATCH, consumes 25KB; the optional TSR, SIDELINE, uses 15KB.

REFEREE can be run at any time from the DOS prompt. Users pick menu selections to activate and deactivate specific TSRs and to load TSRs into memory and unload them at any given time. The documentation cautions that any RAM-resident program that is to be monitored by the REFEREE program must be unloaded from memory via REFEREE's main menu, not through the method supplied by the TSR. If this procedure is not followed, REFEREE will have no way of knowing the status of that program. In addition to controlling the status of each TSR, the menu-driven REFEREE program also shows the amount of memory used by each TSR program and the amount of memory that is available.

Referee also allows users to define sets of TSRs, called RAM teams, that are to be activated, deactivated, or left unchanged while specified programs are run. For example, the user may want certain TSRs enabled and others disabled while using a text editor or running a spreadsheet. Although a spelling checker and a pop-up calculator can be useful while using a word processor, these TSRs can be a nuisance when C code is being entered. RAM teams must be specified through menus in the REFEREE program. First, a user indicates the name of the program used to invoke an application. Next, from a list of TSR programs that are being monitored by Referee, the user selects the status that each TSR should have while the particular application runs. Referee automatically records these specifications in a file for future use.

Referee also accepts command-line arguments for activating, deactivating, loading, and unloading TSRs from the DOS prompt or batch files. As mentioned previously, however, RAM teams can be defined only through the REFEREE menus. In addition, the Referee RAM-resident program, SIDELINE, can be called from within any application, using the Alt key plus hot key. This program can activate and deactivate TSRs and report on their status.

All programs worked well; Referee performed as expected or documented in all situations. It was able to control (that is, enable, disable, and unload) TSRs (such as Borland's SideKick, SuperKey, and Turbo Lightning; Living Videotext's Ready!; and VM Personal Computing's RELAY Gold) as well as DOS TSRs (such as PRINT.COM, GRAPHICS.COM, and keyboard definition programs KEYBxx.COM). In addition, the RAM-team definitions worked well; TSRs were enabled and disabled transparently as particular applications were started or ended.

Referee behaves quite rationally. For example, it won't unload a TSR without requiring that all other TSRs loaded after the specified application also be unloaded. In addition, it will not unload TSRs from a second copy of COMMAND.COM invoked from within an application. However, Referee must work within the limitations of the TSRs themselves. It cannot make incompatible TSRs compatible with one another, for example, and it cannot prevent one TSR from disabling another when it runs. Appropriately defined RAM teams, however, could keep the TSRs from interfering with one another. In this way, a user could be certain that the two conflicting TSR programs were never enabled at the same time.

Referee's documentation is well written and clear. The manufacturer, Persoft, invites technical support calls and sprinkles its phone number throughout the manual. The Persoft people are also honest; while they will try to help, they warn that they may not be able to solve every problem.

With Referee, TSRs can be used effectively and with little disruption. Until OS/2 comes along to overcome the DOS 640KB memory limitation, and in lieu of expensive expanded-memory boards, Referee is a good choice to manage memory-hogging TSRs.

—PAUL FIRGENS

TECH NOTEBOOK

A forum for sharing solutions to technical problems.

1 dBASE FIX

2 OS/2 AUDIO

The readership of *PC Tech Journal* is a very select group, whose collective knowledge of desktop computing leads the industry. Through the years, readers have shared this knowledge with one another through the forum of Tech Notebooks. This column is the successor to that popular series, but in a more flexible format. Here we will present solutions to problems and miscellaneous bits of technical information that are not readily available. We hope the primary source will be you, the readers, but the staff of *PC Tech Journal* will also share its discoveries with you. All complete programs listed in these pages will be available on PCTECHline.

1 dBASE PRINTER REDIRECTION

Our first item, from Joseph C. Krupp, concerns redirecting dBASE III PLUS printer output to a disk file. As was pointed out in *PC Tech Journal*'s review (see "The Evolving Standard," Dave Browning, May 1986, p. 166), the lack of this capability is a flaw in dBASE III PLUS. The solution relies on the fact that dBASE III PLUS is written in C and writes to standard file handles.

Every process, when it is loaded by DOS, receives five open file handles: standard input, standard output, standard error, standard auxiliary, and standard printer. Initially, the first (handle 0) refers to the keyboard, the second and third to the screen, the fourth to COM1, and the fifth (handle 4) to LPT1. Any one of these handles can be redirected to any other device or file. For standard input and output, this can be done at the DOS command line; for the others, it must be done within the program. Fortunately, dBASE III PLUS provides the capability to execute user-written assembly language routines.

The PTOFILE routine shown in listing 1 redirects handle 4, and therefore any printer output, to a user-specified file. It is called with a string parameter giving the name of the file to receive printer output. At entry, DS:BX points to this file-name string.

PTOFILE first closes handle 4, then opens the file passed as the parameter. DOS always assigns the lowest-numbered unused handle to a newly opened file, so this file name will be opened as handle 4. Following C language convention, strings in dBASE III are terminated with nulls, which is the same as the ASCIIZ format that DOS uses in function calls. Upon return to dBASE, all of the output sent to handle 4 will go to the file.

If an error is found in the open call, the error code returned by DOS is converted to a character and placed at the head of the file-name parameter. PTOFILE opens the PRN device, again associating the printer with handle 4. On return to dBASE, the dBASE procedure can determine if an error occurred by comparing the file-name string after the call with a copy of the string saved before the call. The only possible errors are 3, Path not found, and 5, Access denied. The latter usually means that the requested file already exists and is not writable because it is a subdirectory or its attribute is system, hidden, or read-only. Error 4, No handles available, will not occur because handle 4 was just closed.

The dBASE program calling PTOFILE can extract the first character from the file-name string and take action appropriate to the error, as shown in listing 2. Note that this means that the output file name cannot begin with the characters 3 or 5.

If the file-open call succeeds, all subsequent printer output goes to this file. This includes output produced by the dBASE III commands SET PRINT ON and SET DEVICE TO PRINT, and the . . . TO PRINT clause in other output commands such as LIST, LABEL, etc.

To send output back to the printer, call PTOFILE with the string 'PRN.' If the output file is to be processed by the dBASE program, it must first be closed by calling PTOFILE with either 'PRN' or some other file name. The routine also can be used to redirect print output to other devices.

The PTOFILE routine must be assembled and linked, then converted to binary form with EXE2BIN. Note, however, that it is not a COM file, and begins at offset 0, not 100H. The binary file must have an extension of BIN in order for dBASE to load it.

A word of caution about the format of the file holding the redirected print output. In most cases, each line will be terminated with two carriage returns and a line feed, instead of the standard <cr> <lf> pair. For

```
@ 1,0 SAY "Hello"
@ 2,0 SAY "world"
```

dBASE looks first at the relative column position of the second SAY statement and outputs <cr> to get back to column zero after printing "Hello." Then it looks at the line number, and outputs <cr> <lf> to get from line 1 to line 2. The extra carriage returns have no effect if the file is typed to the screen or copied to the printer, but most text processors will convert a lone <cr> to a <cr> <lf> pair, resulting in double-spaced output.

PTOFILE will act differently with versions 1.0 and 1.1 of dBASE III PLUS because of the different methods each version uses to determine printer status. The older version tests status directly from the printer port, regardless of redirection. If the printer is off-line when a SET PRINT ON or SET DEVICE TO PRINT statement is executed, version 1.0 returns the message "Printer not ready. Retry?" If the user replies "N," the printer handle is not activated. Version 1.1 uses an IOCTL function to inquire on the status of handle 4, and

returns the status of the device or file currently associated with that handle. Thus, with version 1.1, PTOFILE can be used to test report generation on a system without a printer.

2 MONITORING MULTITASKING

The second Notebook entry is somewhat more entertaining but can be very useful for experimenting with multitasking in OS/2. It concerns a series of simple C programs that play tunes on the speaker. The purpose of each program is to give an audible indication of when it is running, even when it is switched to the background with no access to the screen. The programs can be linked and bound into OS/2 Family Applications, meaning that they will run under both DOS and OS/2.

The programs demonstrate some simple OS/2 system calls (for a full explanation of the Application Program Interface in OS/2, see "The Flexible Interface," Dave A. Schmitt, November 1987, p. 110). The DOSBEEP function produces a tone on the speaker; its two parameters are the frequency in hertz and the duration in milliseconds. DOSSLEEP suspends program execution for the number of milliseconds given by its single argument; it is used to produce pauses between the notes. Producing recognizable tunes by specifying frequencies requires some nontrivial calculations, so an explanation of the procedure is in order.

The CHROM program in listing 3 plays a chromatic scale, made up of 12 notes in an octave (on a piano keyboard, seven white keys and five black keys). The ratio of frequencies of two notes an octave apart is two; the frequencies of intervening notes are spaced logarithmically equidistant between these, so the ratio of two adjacent notes is the twelfth root of two. This is the value of the variable *hstep* in the program. The program starts with a frequency of 100 Hz, runs up through six octaves to 6400 Hz, then back down, and repeats endlessly. The only way to end it is to press Ctrl-Break when it is in the foreground.

The SCALE program (listing 4) plays a diatonic major scale, the familiar *do-re-mi* kind. This scale proceeds by a series of steps and half-steps, also called whole tones and semitones. A semitone is the ratio of two adjacent notes of the chromatic scale; a whole tone is the square of that. A major scale is defined as a sequence of eight notes in the following pattern: step, step, half-step, step, step, step, half-step. To prevent round-off errors over several octaves, the eighth note of the octave is obtained by doubling the first note instead of by multiplying the seventh note by the half-step ratio. Following musical terminology, the frequency of the first note of each octave is saved in the variable *tonic*.

The third program, ARPEGG (listing 5), plays a series of tones called an arpeggio, consisting of the first, third, and fifth notes of the major scale in each octave. The third note is two steps above the first, the fifth one-and-a-half steps above that.

You may tailor the speed and character of the scale by adjusting the values of the two time parameters, *notetime* and *resttime*. Although in theory any values may be used, in practice they are rounded off to the next multiple of 32 milliseconds (ms), the period of the system clock. Note that this is a finer time resolution than in DOS, where the timer period is 55 ms.

These programs only become useful when run in the background. You can tell immediately when a process is suspended and when it slows down. For example, running screen output in the foreground periodically interrupts the playing in the background, resulting in a scale that moves through the octaves in fits and starts. Variations in regularity and speed of the notes are easily detected by ear, giving a qualitative indication of the impact of one process on another. The ultimate impact, of course, is when the DOS Compatibility Box running one of these programs is switched into the background—the audio output from the DOS box stops, indicating that the real-mode partition is not multitasked when in the background.

These programs have many other uses in the exploration of multitasking. Detaching one of them (that is, starting it as a background-only process) demonstrates that there is no way, short of a system reset, to terminate a detached process. The programs can be used as the targets of DOSEXEC and DOSKILLPROCESS tests, giving instant confirmation of success or failure of these calls. Running them simultaneously allows monitoring up to three concurrent processes, because the tunes are different enough to be easily distinguished even when playing together. If the same time values are used in all three programs, then the relative speeds of the three processes can be estimated from the time each takes for one "sweep of the keyboard."

The programs impose little load on the system, because the durations of beep and sleep intervals are available for executing other tasks. They are therefore ideal measuring tools, hardly affecting the system under test but readily showing the effects of other loads. OS/2, being a new world for most programmers, will require many such testing tools. Creating and using these tools can teach you a lot about the new system.

LISTING 1: PTOFILE.ASM

```
CODE      SEGMENT BYTE PUBLIC 'CODE'
          ASSUME  CS:CODE

PTOFILE   PROC    FAR
          PUSH    BX              ;save pointer to file name
          MOV     BX,4            ;file handle 4, printer
          MOV     AH,3EH          ;DOS close file function
          INT     21H
          POP     DX              ;DX points to file name
          XOR     CX,CX           ;attribute for normal file
          MOV     AH,3CH          ;create/truncate file
          INT     21H
          JNC     EXIT            ;all done if no error
ERROR:    ADD     AL,30H          ;convert error code to character
          MOV     BX,DX           ;filename pointer back to BX
          MOV     [BX],AL         ;put error code into file name
          PUSH    DS              ;save data segment
          MOV     AX,CS
          MOV     DS,AX           ;set DS to this segment
          ASSUME  DS:CODE         ;tell MASM about it
          LEA     DX,STDPRN       ;point to printer device name
          MOV     AH,3CH          ;open the printer device
          INT     21H
          POP     DS              ;restore segment address
EXIT:     RET
PTOFILE   ENDP

STDPRN    DB      'PRN',0         ;device name for printer
CODE      ENDS
          END
```

LISTING 2: REDIR.PRG

```
* This fragment of dBASE III Plus code shows one way to use
* the PTOFILE function for redirecting printer output to a file.
* Here, the user is asked for a name of the file to receive a
* report created with @..SAY commands.  The PTOFILE function
* also affects output resulting from SET DEVICE TO PRINTER
* commands and ..TO PRINT clauses.

LOAD PTOFILE
MSG = 'Enter output file name or CR to use printer '

DO WHILE .T.                        && loop until exit command
  OUTFILE = ''                      && null out filename variable
  ACCEPT MSG TO OUTFILE
  IF LEN(OUTFILE) = 0
    EXIT
  ENDIF
  SAVFILE = OUTFILE                 && save filename for error test
  CALL PTOFILE WITH OUTFILE
  IF OUTFILE = SAVFILE              && OK if filename unchanged
    EXIT
  ENDIF
  ERRNUM = SUBSTR(OUTFILE,1,1)      && get error code
  IF ERRNUM = '3'
    ? 'Path not found -'
  ELSE
    ? 'Access denied -'
  ENDIF
ENDDO

SET DEVICE TO PRINT
:
: report created with @..SAY commands
:
CALL PTOFILE WITH 'PRN'             && restore printer output
```

LISTING 3: CHROM.C

```
/****************************************************************
 * CHROM.C - Program to produce chromatic scale on speaker.     *
 *                                                              *
 *   For OS/2 C compiler, but can be bound into family mode.    *
 *                                                              *
 *   by Ted Mirecki, July 1987                                  *
 ****************************************************************/

#include <doscalls.h>          /* OS/2 function definitions */
#include <math.h>              /* pow() definition          */

int   notetime = 50;
long  resttime = 20L;

double   start = 100.0,
         stop  = 6400.0,
         freq;

main()
{
   double hstep;

   printf("Audible Multitasking Indicator: CHROMATIC SCALE\n");
   printf("Copyright (c) 1987, PC TECH JOURNAL ");
   printf("and Ziff Communications Co.\n");
   printf("  Written by Ted Mirecki\n\n");

         /* half-step frequency ratio = twelfth root of two) */
   hstep = pow(2.0, (double) (1.0/12.0));

   freq = start;

   while (1)                    /* Begin infinite loop */
   {
     for (; freq < stop; freq *= hstep) /* Run up the keyboard */
        note();
     for (; freq > start; freq /= hstep) /* Run down the keyboard */
        note();
   }
}
```

```
        /* Isolate OS calls in separate function  */
note()
{
   int   ihertz;
   ihertz = (int)(freq + 0.5);
   DOSBEEP(ihertz, notetime);    /* Produce tone */
   DOSSLEEP(resttime);           /* Pause between notes */
}
```

LISTING 4: SCALE.C

```
/************************************************************
 * SCALE.C - Program to produce major scale on speaker.     *
 *                                                          *
 *   Can be bound into family mode.                         *
 *                                                          *
 *   by Ted Mirecki, July 1987                              *
 ************************************************************/

#include  <doscalls.h>
#include  <math.h>

int   notetime = 50;
long  resttime = 20L;

double   start = 100.0,
         stop  = 3200.0,
         freq;

main()
{
   double hstep, tonic;
   int n;

   printf("Audible Multitasking Indicator: MAJOR SCALE\n");
   printf("Copyright (c) 1987, PC TECH JOURNAL ");
   printf("and Ziff Communications Co.\n");
   printf("  Written by Ted Mirecki\n\n");

         /* half-step frequency ratio = twelfth root of two) */
   hstep = pow(2.0, (double) (1.0/12.0));

   while (1)                           /* Begin infinite loop */
   {                                   /* Run up the keyboard */
      for (tonic=start; tonic<=stop; tonic*=2.0)
      {                                /* Play ascending octave */
         freq = tonic;
         note();                       /* do */
         freq *= hstep*hstep;          /* full step */
         note();                       /* re */
         freq *= hstep*hstep;          /* full step */
         note();                       /* mi */
         freq *= hstep;                /* half step */
         note();                       /* fa */
         for (n=1; n<4; n++)           /* 3 more full steps */
         {
            freq *= hstep*hstep;
            note();                    /* so, la, ti */
         }
      }
      for (; tonic>=start; tonic/=2.0) /* Run down the keyboard */
      {                                /* Play descending octave*/
         freq = tonic;
         note();                    /* do */

         freq /= hstep;             /* half step */
         note();                    /* ti */
         for (n=1; n<4; n++)        /* 3 full steps */
         {
            freq /= hstep*hstep;
            note();                 /* la, so, fa */
         }
         freq /= hstep;             /* half step */
         note();                    /* mi */
         freq /= hstep*hstep;       /* full step */
         note();                    /* re */
      }
   }                                /* end of while 1 */
}
```

```
        /* Isolate OS calls in separate function  */
note()
{
   int ihertz;
   ihertz = (int)(freq + 0.5);
   DOSBEEP(ihertz, notetime);        /* Produce tone */
   DOSSLEEP(resttime);               /* Pause between notes */
}
```

LISTING 5: ARPEGG.C

```
/******************************************************************
 * ARPEGG.C - Program to produce arpeggio on speaker.             *
 *                                                                *
 *   For OS/2 C compiler, but can be bound into family mode.      *
 *                                                                *
 *   by Ted Mirecki, July 1987                                    *
 *                                                                *
 ******************************************************************/

#include  <doscalls.h>
#include  <math.h>

int   notetime = 50;

long  resttime = 20L;

double    start = 100.0,
          stop  = 3200.0,
          freq;

main()
{
   double hstep,
          tonic;

   printf("Audible Multitasking Indicator: ARPEGGIO \n");
   printf("Copyright (c) 1987, PC TECH JOURNAL ");
   printf("and Ziff Communications Co.\n");
   printf("  Written by Ted Mirecki\n\n");

        /* half-step frequency ratio = twelfth root of two) */

   hstep = pow(2.0, (double) (1.0/12.0));

   while (1)                          /* Begin infinite loop */
   {                                  /* Run up the keyboard */
      for (tonic=start; tonic<=stop; tonic*=2.0)
      {                               /* Play ascending octave */
         freq = tonic;
         note();                         /* C */
         freq *= hstep*hstep*hstep*hstep;  /* 2 full steps */
         note();                         /* E */
         freq *= hstep*hstep*hstep;      /* 1.5 steps    */
         note();                         /* G */
      }

                                      /* Run down the keyboard */
      for (; tonic>start; tonic/=2.0)
      {                               /* Play descending octave*/
         freq = tonic;
         note();                         /* C */
         freq /= hstep*hstep*hstep;      /* 1.5 steps    */
         note();                         /* G */

         freq /= hstep*hstep*hstep*hstep;  /* 2 full steps */
         note();                         /* E */
      }
   }                                     /* end of while 1 */
}

        /* Isolate OS calls in separate function  */
note()
{
   int ihertz;
   ihertz = (int)(freq + 0.5);
   DOSBEEP(ihertz, notetime);        /* Produce tone */
   DOSSLEEP(resttime);               /* Pause between notes */
}
```

MOVING?

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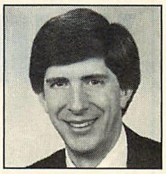


OUTFITTING THE END USER

The Big Game Begins

The boundaries are becoming obscured as the PC works its way into the major leagues.

In the continuing contest of computing, the warmups are finally over. The time has come to get serious about making information informative, and that is going to mean big changes from the PC point of view.

So far, we have had two separate playing fields: small systems and big iron. Each group scrimmaged among themselves but rarely admitted the other existed. Our limited micro–mainframe integration has been about as meaningful as one group throwing back the other's ball when it falls in their field by mistake.

Lately, however, we see some crossover: corporations are accepting PCs and other workstations as part of the system, not just as an end-user knickknack; vendors are increasingly going on-line (for example, typesetters are taking copy on disk or even lending out PCs to prepare it); several universities are requiring students to own computers as a condition of enrollment; the Internal Revenue Service is getting ready to accept tax returns via modem, and even elected congressional representatives are using bulletin boards for conducting digital discussions with constituents.

We also see a major manufacturer betting what is left of its PC market share (ahem!) on a strategy that seeks to dissolve the boundaries between desktop and mainframe computing: those due both to limited connectivity and to differences in user interface. PCs no longer are viewed as mere smart terminals. Rather, the mainframes are quickly becoming shared peripherals for the PCs, making distributed computing at last a literal term and not just a marketing buzzword. When a single 80386-based PC can serve as a "mainframe" for a small office full of users, at a cost competitive with yesterday's stand-alone PCs, you don't have to be in the Fortune 500 to be interested in micro–mainframe coordination.

The binders of genuine acceptance are there, though the terms may still be negotiated. Highly distributed computing is not just in the game; increasingly, it is the game.

NO MORE EASY POINTS

Having a computer on your desk used to be like being the only caveman in the valley who knew how to make a fire. The difference between something and nothing was enough to make you pretty special.

Today, however, the AT clone is ubiquitous; enough of them are out there to make spreadsheet jockeys a dime a dozen. Just having a computer is no longer enough; the difference between mere adequacy and a true competitive edge is the difference between playing on a sandlot and playing underneath a domed stadium.

Power computing in the 1990s will involve using different size machines for different parts of the job, but then mixing the results together. Tomorrow's users will want to move data at will to whatever system can do what they want—and by *system* I mean the right software (both concept and features), running on an adequately powerful machine, connected to the right sources of data. No more putting up with an inadequate tool because it happens to work on the one machine you have on your desk; no more retyping data from printout *A* on keyboard *B*.

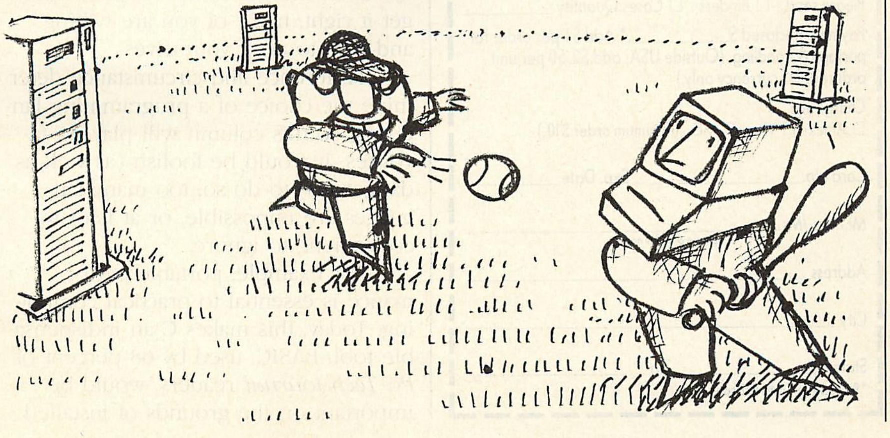
Conversely, though, we would also be happy to eliminate the all-night downloads of mainframe data sets to process on PCs. We would rather have true cooperative processing, with applications that span many machines and a minimum of raw data transfers.

The easy points have all been won. Improved technology and lower costs may make getting into the game easier, but looking like a winner will never be quite so easy again.

DECLARATIONS

With all of this in mind, *PC Tech Journal* has invited me to add another perspective to the magazine in the form of this new monthly column. "A column? What about?" ask innocent friends and colleagues. What, indeed.

As you see from the column's name, the editors and I have agreed on a broad charter: Outfitting the End User. We do not mean outfitting in the sense of a fancy suit, but rather in the sense of Abercrombie and Fitch equipping a safari. Tomorrow's user will need the same combination of powerful, rugged tools that explorers need



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for physical frontiers. People like you will be advising those users on what to take along (and, just as important, advising them how to use it).

Another, growing part of outfitting is akin to maintaining a long hiking trail—that is, recognizing and clearly marking safe, direct paths from one point to another. As desktop computers leave the realm of novelties and become widespread "information appliances," organizations will find they must invest in information assets that are much like trails and shelters: the shared resources such as networks and data dictionaries.

These get bought (or built) in much larger chunks, especially in the case of networks, than had been previously the case when buying stand-alone computers. They are also expected to last much longer than the incremental investments (with short product life cycles) that we have all been making for the last five years. Under these conditions, if you are wrong it is really going to hurt.

So where will our discussions, using this column as our forum, lead us? I will tell you this: you are the kind of audience that gives a writer cold chills. Editor Julie Anderson gave me a copy of a recent subscriber study; let me tell you a little about yourselves, filtered through my own ideas of what it is that makes you interesting.

First, you are not afraid to tell your machine what you want. You spend an average of 18 hours a week programming, with only about one-third reporting fewer than 10 hours.

Furthermore, you can command your machine in whatever language will get its attention. You use an average of almost three languages apiece on your micros (with 70 percent of you reporting regular programming on minicomputers and mainframes as well). If MicroTate-Protus (or whatever the latest merger has produced) can't get it right, many of you are willing and able to do it yourselves.

Preference and circumstance determine the choice of a programming language, so this column will play no favorites. It would be foolish (as well as dangerous) to do so; too many languages are impossible, or at least inconvenient, to ignore.

For example, portable performance is essential to practical computing. Today, this makes C an indispensable tool. BASIC, used by 68 percent of *PC Tech Journal* readers, would be important on the grounds of installed base alone, but the language continues to mature and to be favored with increasingly sophisticated implementations. Even FORTRAN, COBOL, and other production languages present outfitting issues—for example, the impact of recent or planned revisions to their respective standards. And Ada gets pushier every day, even outside the Defense community. No, the languages of this column will be many, and they will be varied indeed.

This will not be a programming column as such—plenty of those are around already. But I will try to dig into the dilemma of exploiting productive new ideas, such as objects and modules, without abandoning or rewriting existing code. (That does not necessarily mean we will find ways to make the transition cheaper; I would settle for finding out when the benefits can be expected to justify the costs.)

I will also look for ways to deal with the widely discussed software crisis—for example, unacceptable backlogs in development groups and undocumented, untested, and inconsistent end-user programs. How can we get users closer to the development process (when actual end-user programming is unattractive) so that the program they get actually does what they want? Does rapid prototyping make a productive difference, or does it just substitute conspicuous motion for quieter but more genuine progress? Suggestions, anecdotes, and pointers to published studies are invited.

Alternatively, how do we get beyond the spreadsheet to tools that will not intimidate non-programmers, while at the same time reducing today's high level of invisible errors that produce plausible but incorrect results? Or should we, just possibly, be placing less emphasis on tools for everyone and more emphasis on programmable environments that can be customized by an expert to automate the individual routines of an office?

AI: BRAINS FOR THE MACHINE?

Speaking of languages, it was a surprise to see that 12 percent of you report personal use of LISP, with Prolog close behind at 9 percent. While both LISP and Prolog can be quite useful outside the realm of artificial intelligence, I think it is reasonable to assume that most of you are using these languages to explore AI techniques.

I also see 13 percent of you plan to purchase "Expert Systems/AI" software in the next 12 months, which ties

the figures for the "Statistics" and "Integrated" categories and exceeds the percentages for "Accounting" and "Decision Support." By this measure, the AI market really seems to be emerging.

Furthermore, many of the claims for AI sound like possible answers to the software crisis that I mentioned before, with benefits anticipated for developer and user alike. More rapid development of programs that tolerate user error and ambiguous data . . . it is an awfully attractive bundle.

Making AI real is what I do for a living when I am not writing columns. This means defining problems, building databases, creating networks. Only then does it make sense to construct an expert system or other appropriate tool.

This is expensive; I know how hard it is to do meaningful AI work outside a laboratory, so I will deliver no AI hype. On the other hand, the potential practicality of AI represents a vital opportunity. For example, companies could capture the expertise of key people nearing retirement, or industries could improve their competitiveness with more effective use of their resources. Helping you make decisions that leave your AI options open (or even let you begin to take advantage of them today), is one more mandate that this column has.

SEEING IS CONCEIVING

Another interesting aspect about your taste in languages is that almost 10 percent of the total microcomputer programming activity among *PC Tech Journal* subscribers is in big-iron languages such as LISP, Ada, COBOL, and PL/1—languages that supposedly everyone knows you can't use for real work on a micro. So at least 10 percent of you defy this conventional wisdom, recognizing the importance of interactive environments, not just big CPUs.

More consistent response time was probably the key initial benefit for people doing micro-based development (even for mainframe delivery), but the special advantages of close coupling with the display were seductive. Today, even production languages like FORTRAN and COBOL benefit from slick, animated debuggers on PCs. Whether programmers or users, many of us seem to think more clearly about what we can see and "touch" in visual environments than what we can only talk about on command lines.

Clearly, improved interaction with the system is one of the hot topics in computing. When Apple introduced the Macintosh, it was common to ridicule the large fraction of CPU resources devoted to managing the user interface. Users put up with the (supposed) reduction in performance because they were getting what they wanted with less time and effort—even on this "slower" machine.

This issue was therefore high on the agenda when the Personal Computer Professionals Association, whose member companies are using mostly MS-DOS machines, devoted a meeting to "The Future of Personal Computing." At that meeting, one speaker suggested that as much as 80 percent of future growth in overall PC power might be achieved through interface improvements, rather than through higher computational performance.

That ratio looks more and more realistic in light of recent experience. Today's advanced environments may need 80286- or even 80386-class CPUs to produce the same screen-scrolling performance we used to get on an 8088 using plain old dirty code. A six- to ninefold increase in raw system power, just to break even on one of the most visible measures of performance, translates to an interface burden of more than 85 percent.

Even Microsoft is sending loud, explicit warnings that simple tasks under OS/2 will be slower than the same tasks under plain old DOS. Someone out there thinks that speed is less important than doing what you want, when you want, in an environment that lets you see what you are doing and do more with the results.

THE WORKSTATION OPTION

It may surprise you to learn that 19 percent of you out there already have those so-called "supermicros" (Suns, Apollos, VAXstations) on site; those sites average 93 such machines apiece. (Compare this with the 78 percent of you with 286-based machines on site, averaging 151 per site.) I find this "bow wave" of workstations extremely interesting, because this class of machine has an important window of opportunity—no pun intended—over the next year or two.

What, after all, does a workstation bring to the party? Most of them have a 68020 or comparable CPU, with the 386 gaining ground, for performance on the order of 3 million instructions per second (MIPS). They typically run multitasking operating systems, with windowing environments that provide

varying degrees of graphic user interface and some degree of coupling between different applications.

Most workstation-class machines support big, flat memory spaces: tens of megabytes of physical memory, if desired, and several factors more of virtual. Most also offer integrated networking. Even most machines with non-Intel CPUs can run DOS applications using a coprocessor card.

IBM and Microsoft have been trying hard to persuade us that these features are important. Not that I was at all a hard sell; for the past four years I have been using DESQview, Framework, EEMS memory, and the Mac.

Thanks to recent major price reductions in the workstation market, however, the workstations I can buy today are surprisingly competitive with the OS/2 platforms that will give me similar capability . . . someday (however, I have been astonished by the rapid commitment of the software industry to OS/2 and of the hardware community to boards for the PS/2's Micro Channel; I may have overestimated the market's inertia).

Granted, hardware price and performance are not the only legitimate issues. That is not sarcasm; initial acquisition cost is a tiny fraction of the lifetime cost of ownership, and the availability of quality software off the shelf at mass-market prices makes up for a lot of raw performance potential. UNIX and its derivatives may make appreciable inroads in the 286 and 386 markets during the OS/2 gestation, though this is looking like a shorter wait every day; if the UNIX/XENIX/POSIX installed base gets big enough, the relative costs of the applications and the tools may change dramatically.

Ease of use, another issue for the infamously cryptic UNIX environment, is largely a matter of providing the right support facilities; a larger installed base may finally make this a commercially attractive project.

MANAGEMENT, NOT MANIA

Another interesting characteristic of *PC Tech Journal* readers is the number with job titles that are classified by the survey firm as "Top Management" or "Management/Administrative." Almost half of you fall into these two groups (with the rest being mostly "Professional/Technical").

Some of my most intensely grueling moments have been during briefings to senior management. It is difficult to shake a perception that one is a

PC advocate, rather than a professional making recommendations based on demonstrable cost effectiveness—that is recommendations that recognize limits on the ability of other operational systems, and of an organization's people, to make productive use of these new capabilities.

For this reason, our future discussions will describe some of the planning models that I have seen and/or developed—methods for persuading management that there are actually objective ways to establish an optimum rate for bringing PCs into an organization. (Hint: "What have you got to spend?" does not rank as one of the input prompts.)

Simulation is another technology that deserves more attention. The simulation role of the spreadsheet is well known. Keeping simulations from becoming fairy tales and wish lists is high on my list of the computing community's "structural" problems, so I will give special attention to new ideas and products that address this point.

Next month, for example, I want to talk about the environment. Not the one that James Watt wanted to protect from the Beach Boys, but the one where you and I spend (presumably) our most productive hours, the world whose crust is our monitor screen and whose mineral rights require very deep drilling to exploit. Through a combination of circumstance and choice, I have had to build homes in a variety of computing neighborhoods over the last few years; next month, I will review what I liked about each, concentrating on ways to combine their advantages using tools readily available on PCs.

So, as the Roman emperors used to say, "Let the games begin." The consequences of failure then were worse than the consequences now, but somehow that is small consolation. I hope we can all give each other a lot to think about in months to come.

I hope you will give me plenty of corrective feedback. Write me care of *PC Tech Journal*, or at SolveWare (Box 1246, Redondo Beach, CA 90278). I can't promise individual replies, but I will try to respond to your suggestions—where it counts—in what you see covered here.

Peter C. Coffee is managing partner of SolveWare, a developer and business computing consultant, and is active in AI and distributed computing applications for aerospace and educational clients.

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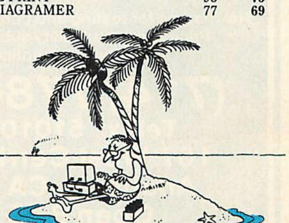

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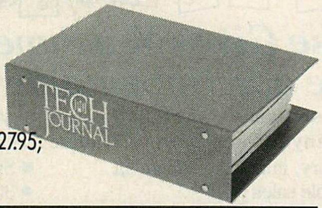

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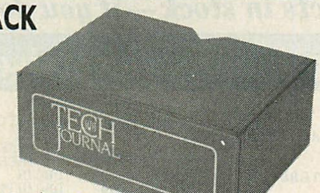

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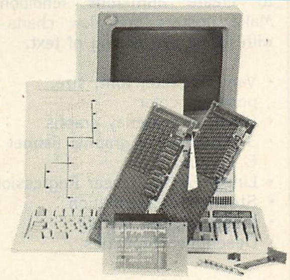

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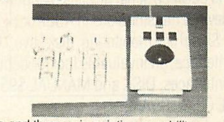

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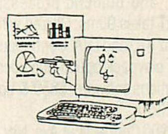

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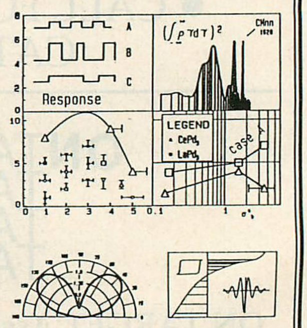

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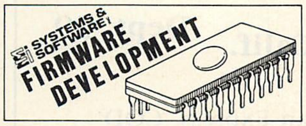

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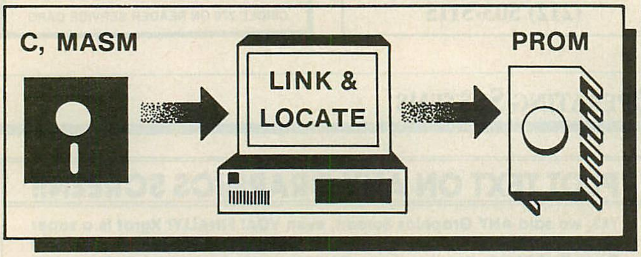

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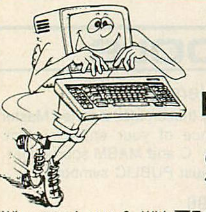

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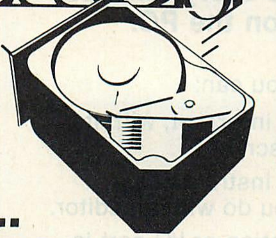

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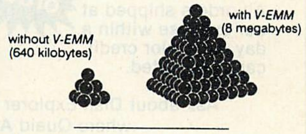

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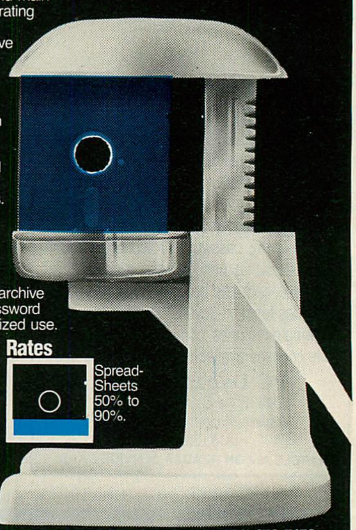

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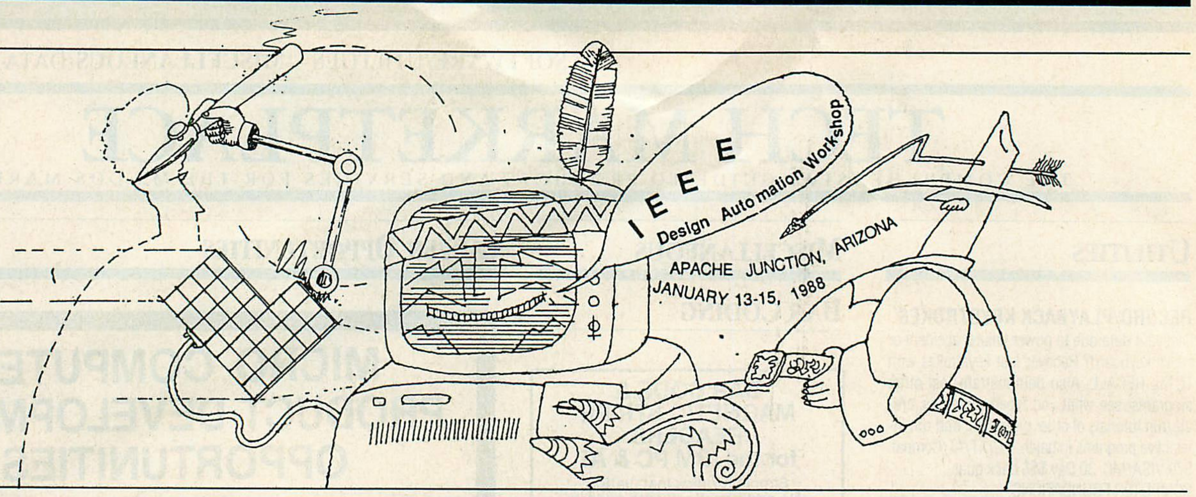

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JANUARY

January 5–8
Hawaii International Conference on System Sciences
Kailu-Kona, HI (IEEE-CS) *Contact:* Ralph H. Sprague, Jr., Decision Sciences Dept., University of Hawaii, 2404 Maile Way, E-303, Honolulu, HI; 808/948-7430

January 10–17
Optoelectronics and Laser Applications
Los Angeles, CA (SPIE) *Contact:* Jane Lybecker, SPIE, P.O. Box 10, Bellingham, WA 98227; 206/676-3290

January 12–13
OS/2 Forum: Preparing for the Next Generation
St. Louis, MO (Center for the Study of Data Processing) *Contact:* Tammy Robinson, CSDP, Washington University, Campus Box 1141, 1 Brookings Drive, St. Louis, MO 63130; 314/889-5380

January 13–15
Design Automation Workshop
Apache Junction, AZ (IEEE-CS) *Contact:* Walling Cyre, Control Data, HQM 173, P.O. Box 1249, Minneapolis, MN 55440; 612/853-2692

January 13–15
Symposium on Principles of Programming Languages
San Diego, CA (ACM, SIGACT, and SIGPLAN) *Contact:* Jeanne Ferrante, IBM Hawthorn H2-B54, Box 218, Yorktown Heights, NY 10598; 914/789-7529

FEBRUARY

February 2–5
International Conference on Data Engineering
Los Angeles, CA (IEEE-CS) *Contact:* Benjamin W. Wah, Dept. of EE and CE, University of Illinois, Urbana, IL 61801; 217/333-3516

February 8–11
UniForum '88
Dallas, TX (The International Network of UNIX Users) *Contact:* UniForum '88, 2400 E. Devon Avenue, Suite 205, Des Plaines, IL 60018; 800/323-5155; 312/299-3131

February 16–18
DEXPO East '88 Conference
New York, NY (Expoconsul International) *Contact:* Expoconsul International, Inc., 3 Independence Way, Princeton, NJ 08540; 609/987-9400

February 22–24
Computer Graphics New York
New York, NY (Exhibition Marketing and Management, Inc.) *Contact:* EMM, Inc., 8300 Greensboro Drive, Suite 1110, McLean, VA 22102; 703/893-4545

February 23–25
Computer Science Conference
Atlanta, GA (ACM) *Contact:* Dr. Richard A. DeMillo, Program Chairman, Software Engineering Research Center, Georgia Institute of Technology, Atlanta, GA 30332; 404/894-3180

February 29–March 4
Compcon Spring '88
San Francisco, CA (IEEE-CS) *Contact:* Hasan AlKhatib, Dept. of EECS, U. of Santa Clara, Santa Clara, CA 95053; 408/554-4485

MARCH

March 3–4
LISP: Expert Systems Tools
Atlanta, GA (Georgia Institute of Technology) *Contact:* Deidre Mercer, Education Extension Services, Georgia Tech, Atlanta, GA; 404/894-2547

March 7–10
Computer Workstations
Santa Clara, CA (IEEE-CS) *Contact:* Patrick Mantey, 335A Applied Science Bldg., Dept. of Computer Engineering, University of California at Santa Cruz, Santa Cruz, CA; 408/429-2158

March 8–10
Technical Conference for MIS/DP Professionals
New York, NY (Cahners Exposition Group) *Contact:* Cahners Exposition Group, 999 Summer Street, Stamford, CT 06905; 203/964-0000

March 8–10
Southcon '88 Electronic Show and Convention
Orlando, FL (IEEE and ERA) *Contact:* Electronic Conventions Management, 8110 Airport Blvd., Los Angeles, CA 90045; 213/772-2965

March 8–11
International Symposium on Digital Communications
Zurich, Switzerland (IEEE-CS) *Contact:* Secretariat 1ZS 88, c/o P. Gunzburger, Hasler AG, TDS, Belpstrasse 23, CH-3000, Bern 14, Switzerland; 41-31-632808

March 10–11
APPC Communication
San Francisco, CA (Systems Technology Forum) *Contact:* Sherry Armstrong, Seminar Coordinator, Systems Technology Forum, 10201 Lee Highway, Suite 150, Fairfax, VA 22030; 800/336-7409; 703/591-3666

March 14–17
National Conference on Ada Technology
Washington, DC (U.S. Department of Defense) *Contact:* Al Rodriguez, U.S. Army Communications-Electronics Command, Fort Monmouth, NJ 07703; 201/532-4725

March 20–24
NCGA Annual Conference and Exhibition
Anaheim, CA (National Computer Graphics Association) *Contact:* NCGA, 2722 Merrilee Drive, Suite 200, Fairfax, VA; 703/698-9600

March 21–23
Computer Standards Evolution: Impact and Imperatives
Arlington, VA (IEEE-CS) *Contact:* Computer Standards Conference, IEEE, 1730 Massachusetts Avenue, NW, Washington, DC 20036-1903; 202/371-0101

March 21–25
World Users Conference
Los Angeles, CA (MacNeal-Schwendler Corporation) *Contact:* MacNeal-Schwendler, 815 Colorado Blvd., Los Angeles, CA 90041; 213/258-9111

March 28–31
World Congress on Computing
Chicago, IL (Interface Group) *Contact:* The Interface Group, Inc., 300 First Avenue, Needham, MA 02194; 617/449-6600

March 29–31
Conference on Optical Storage of Documents and Images
Washington, DC (Rothchild Consultants) *Contact:* Rothchild Consultants, 256 Laguna Honda Blvd., San Francisco, CA 94116-1496; 415/681-3700

APRIL

April 11–13
Computer Networking Symposium
Arlington, VA (IEEE-CS) *Contact:* George K. Chang, 6 Corporation Place, Piscataway, NJ 08854; 201/699-3879

April 11–15
International Conference on Software Engineering
Raffles City, Singapore (IEEE-CS, NCB, and ACM) *Contact:* Tan Chin Nam, 71 Science Park, Singapore 0511; 65/772-0200

April 11–15
COMPEURO '88
Brussels, Belgium (IEEE-CS) *Contact.* Jacques Tiberghien, VRIJE Universiteit Brussels, Pleinlaan 2, 1050 Brussels, Belgium; 32-2-641-29-05

April 25–28
International Conference on Expert Database Systems
Tysons Corner, VA (George Mason University) *Contact:* Edgar H. Sibley, George Mason University, ICSE Department, 4400 University Drive, Fairfax, VA 22030; 703/323-2779

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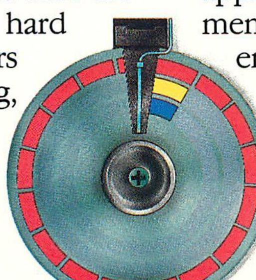

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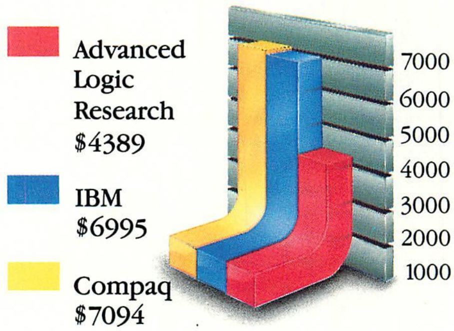

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- Desktop or floormount
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- 8 expansion slots
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and here

and here

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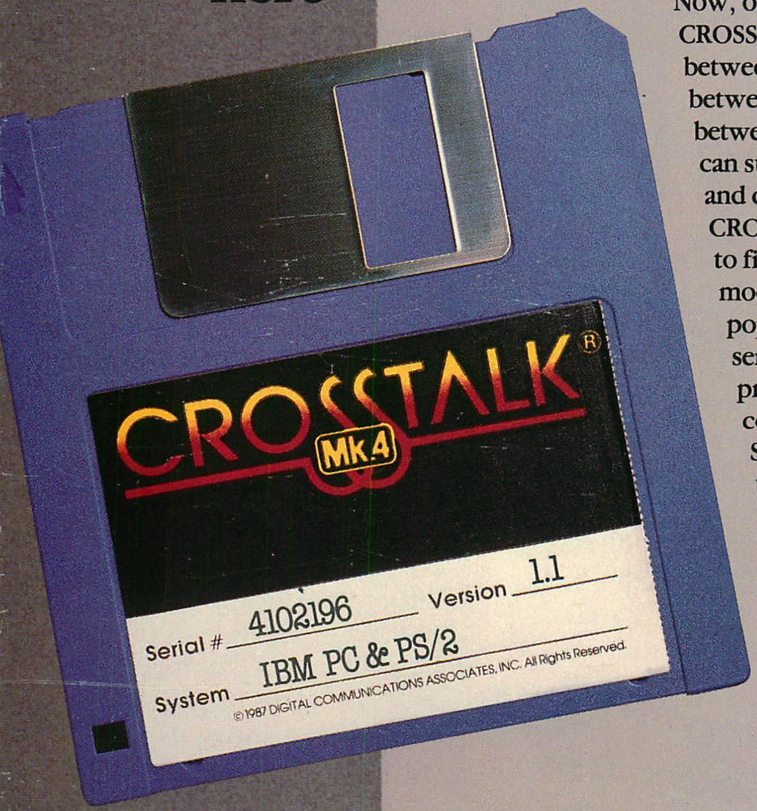

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